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SURGICAL TREATMENT OF AORTIC ANEURYSMS*

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Aneurysm of the aorta is a serious disease causing distressing symptoms and ultimate death from rupture. Prognosis in aortic aneurysm depends to some extent upon the location and nature of the lesion, but in general, once symptoms appear, death occurs within a year or so in the majority of cases. In aneurysms of the thoracic aorta, for example, the average period of survival after diagnosis has been found to be 6 to 8 months[14]. While life expectancy for abdominal aneurysms, predominantly arteriosclerotic in type, is somewhat better, about a third of the patients die within the first year after diagnosis—mostly from rupture[12]. Rarely even a patient with ruptured abdominal aneurysm will survive, but in the vast majority the condition is rapidly fatal within the first few hours or days. Prognosis in dissecting aneurysms of the aorta is almost as grave as for ruptured aneurysms. Thus, according to the excellent study by Shennan[18] of patients with dissecting aneurysm, death ensued within 24 hours after onset in 58 per cent and in 1 day to 1 week in 26 per cent. Others[15, 20] have reported that about 75 per cent of patients died within 60 days and the remaining 25 per cent developed the chronic or so-called healed form of the disease, and survived 3 months to 8 years. In summary then, dissecting aneurysm may be considered fatal in from 75 to 90 per cent of the cases. On the basis of these data it is apparent that aortic aneurysm compares with other highly lethal diseases in regard to morbidity and threat to life, and an aggressive surgical approach to such lesions is justifiable wherever the general condition of the patient permits.

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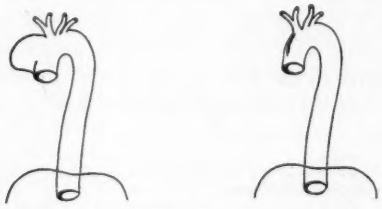
Surgical methods employed until recently, and designed primarily to promote thrombosis within the sac or to reinforce the wall of the aneurysm, have proved generally unsatisfactory and, for the most part, have been discarded. During recent years excisional therapy of aortic aneurysms which provides a direct curative attack has been established as the most effective method for such lesions. Actually the underlying principles of arterial excision were well developed by experimental workers and even advocated and sporadically applied by a few surgeons near the turn of the century. For aortic lesions, however, little consideration was given to the method of excisional therapy at this early date. Tuffier[19], in 1902, occluded the neck of a sacciform aneurysm of the ascending aorta by sutures without excising the sac, but unfortunately the patient died 10 days later from secondary hemorrhage, probably because of gangrene of the sac and infection. Nevertheless, he was convinced of the rationale of aortic aneurysmectomy and recommended the procedure. In 1910, Carrel[1] predicted that on the basis of experimental observations extirpation of aortic aneurysms was rational and believed that aortic repair was feasible under these circumstances, but unfortunately no significant clinical efforts of this type were made. Revival of interest in aortic surgery occurred within the past decade, when Gross[13] and Crafoord and Nylin[7] in 1945 first reported successful excision of a coarctation with end to end anastomosis. Subsequent developments in vascular surgery followed rapidly, and the concept of excision of aortic lesions was extended to aneurysms, as well as obliterative or occlusive lesions. We, like others, began approximately 5 years ago to apply this principle for almost all aortic aneurysms with increasingly gratifying results[2]. This report is concerned with our experience with excisional therapy during the period between July 1951 and Feb. 1, 1956.

Details in the technic of excisional therapy have been described in previous reports[2-4, 6, 9-11] but certain aspects deserve brief consideration. The actual method of excision employed in the individual case depends largely upon the nature and location of the lesion. Tangential excision and lateral aortorrhaphy is employed in sacciform aneurysms, usually syphilitic in origin, where only a portion of the circumference of the vessel is involved by the disease process (fig. 1). After careful isolation of the neck of the aneurysm a long-bladed occluding clamp is tangentially applied following which the sac is evacuated and



21 Patients

Fig. 1. Drawing showing the method of tangential excision of sacciform aneurysms of the aorta with lateral aortorrhaphy.

excised. In most syphilitic aneurysms of this type the adjacent aorta is relatively leathery in consistency and can be sutured without difficulty. This method of repair is particularly suited for aneurysms of the ascending aorta because aortic flow can be maintained continuously during the procedure. Tangential excision also may be used for lesions of the distal aortic arch and descending thoracic aorta in those instances where conditions are favorable, but segmental aortic resection frequently is used even for sacciform aneurysm in this location.

In fusiform aneurysms, either arteriosclerotic or syphilitic in origin, in which the entire circumference of the aorta is involved, segmental resection with restoration of continuity by graft is the procedure of choice (fig. 2). In general this method consists in temporary interruption of aortic flow by cross-clamping proximal and distal to the lesion while the diseased segment is excised and replaced with an aortic homograft. This method was first used successfully in the abdominal aorta where resection of the bifurcation was accomplished with restoration of flow into both common iliac arteries. With increasing experience and later with the development of hypothermia similar procedures may now be successfully performed in the thoracic aorta as high as the origin of the left subclavian artery. The two regions of the aorta presenting the greatest technical problems in application of this method of therapy are the ascending aorta or proximal aortic arch and the proximal abdominal aorta at the level of major

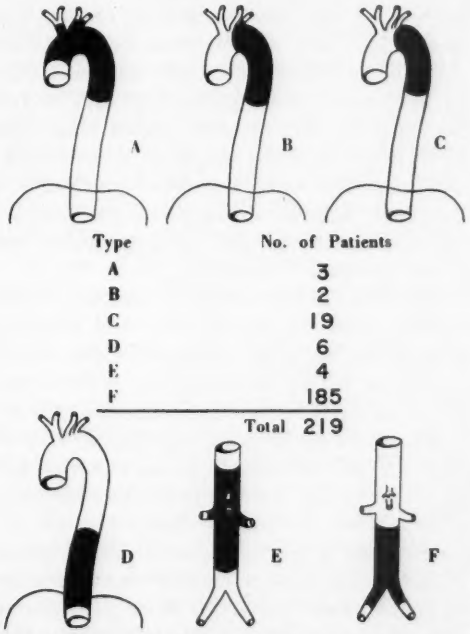


Fig. 2. Drawing showing the method of restoration of aortic continuity after segmental resection for fusiform aneurysms at various levels.

tributaries supplying abdominal viscera. Ischemic injury to organs located distal to the point of temporary aortic occlusion is the major limiting factor in successful application of this technic to lesions of the thoracic and proximal abdominal aorta, and effective control of this problem is crucial in determining success of the operation.

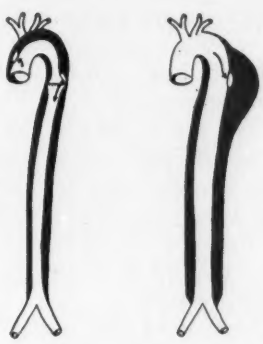
The central nervous system is the most vulnerable tissue to injury from temporary ischemia, and in general, the level and duration of occlusion of the aorta determine the extent and severity of neurologic sequelae. Although the usual safe interval for occlusion of the proximal descending aorta has been estimated to be approximately 15 to 30 minutes, the variation in arterial supply to the cord in addition to other local and systemic factors may lead to paraplegia and even death following briefer periods of occlusion. Fortunately this threat assumes less importance in aneurysms of the terminal thoracic aorta and is almost negligible in abdominal aneurysms if aortic occlusion is not unnecessarily prolonged.

For lesions located in the proximal thoracic aorta measures are employed in all patients to control the threat of ischemic damage to the spinal cord. Technical steps in the operation designed to minimize the period of occlusion are important, and usually the period of occlusion in these cases is less than 1 hour. Other solutions to this problem, including the use of hypothermia and of temporary shunts to conduct aortic flow around the occluded segment, also are employed. Hypothermia by reducing the arterial oxygen requirement of the central nervous system has been demonstrated both experimentally[16, 17] and clinically[5] to prolong the period of safe aortic occlusion. Accordingly, hypothermia is used for aneurysms involving the distal half of the arch and proximal descending thoracic aorta, but for most lesions located distal to the level of the eighth or ninth dorsal vertebra operation is performed at normal body temperature. Hypothermia also exerts a protective influence upon the kidney and liver during temporary arterial occlusion and therefore is employed where the aneurysm involves the proximal abdominal aorta and requires temporary interruption of the corresponding vessels[12].

Temporary external shunts are necessary in resection of fusiform aneurysms located in the ascending aorta or proximal aortic arch where even brief periods of occlusion of the ascending aorta can be rapidly fatal due to severe left ventricular strain and cardiac failure, as well as to cerebral ischemia. Thus, for fusiform aneurysms involving the ascending aorta and arch a temporary shunt is attached to the side of the aorta proximally and distally with branches sutured into the carotid arteries[6]. During the period of aortic occlusion, therefore, the shunt conducts blood to the descending thoracic aorta, and also provides adequate cerebral circulation. Temporary shunts are not used in aneurysms of the descending aorta since hypothermia is considered adequate for this purpose. In 4 cases of thoracoabdominal aneurysm where the celiac axis, renal and superior mesenteric arteries were involved, a shunt was attached to the thoracic and abdominal aorta, proximal and distal to the lesion, thereby significantly reducing the period of total renal ischemia and apparently controlling the ex-

4 Patients

FIG. 3



9 Patients

FIG. 4

Fig. 3. Drawing showing a dissecting aneurysm in which the intimal tear occurred in the ascending aorta and the method of surgical repair.

Fig. 4. Drawing showing a dissecting aneurysm in which the intimal tear occurred in the aorta distal to the aortic arch and the method of repair.

tent of renal insult[11]. The temporary shunts used in these cases are made of compressed polyvinyl Ivalon® sponge in most instances, but heterografts and homografts also are used for this purpose in some instances.

The concept of surgical treatment of dissecting aneurysm is based upon the unique pathogenesis of this type of aneurysm produced by intramural separation of the aortic layers. Degeneration of the medial elements of the aortic wall predisposes to tear or rupture of the intimal coats, occurring usually in the aortic arch just above the aortic valve or in the region of the ligamentum arteriosum or subclavian artery. The forceful stream of blood causes separation of the aortic wall usually in the medial layer which continues circumferentially and may extend throughout the length of the aorta (figs. 3 and 4). Dissection may occur rapidly, resulting in perforation of the outer layer of adventitia into the mediastinum, pleural or peritoneal cavities, or into the pericardium. In some instances the intramural dissection causes compression or shearing off of aortic tributaries. Under these conditions, occlusion of renal arteries may lead to uremia, neurologic signs may occur from spinal cord ischemia, or complete occlusion of the iliac arteries may cause symptoms and signs suggestive of saddle embolus. In those patients fortunate enough to survive dissecting aneurysm re-entry of the intramural passage into the true lumen may be responsible for arrest of the dissecting process. Thus, the surgical procedure which was employed in some of our cases was based upon nature's method of healing, an opening for re-entry of the dissected passage being made at some distal point in the aorta, permitting restoration of peripheral circulation and removing the increasing tension upon the outer wall in order to prevent its rupture (fig. 3). If the origin of the intimal and medial tear is in the ascending aorta or proximal arch a re-entry passage is created at a point distal to the left subclavian artery with obliteration of the false passage below. This is accomplished by

cross-clamping and dividing the aorta, approximating the outer and inner layers in the distal segment and excising a small segment of the inner layer to provide the re-entry passage in the proximal segment. Then end to end anastomosis is done to complete the operative procedure.

In cases in which the dissection begins near the origin of the left subclavian artery a more curative method based upon somewhat the same principle is used, excising that segment of vessel where the dissection originates, obliterating the distal false passage and restoring aortic continuity with a homograft (fig. 4). During the postoperative period efforts to control hypertension are stressed to prevent rupture of the weakened outer wall until it gains adequate support from periaortic fibrous tissue reaction.

Aortic continuity may be restored after segmental resection of the aorta by means of arterial grafts or by synthetic prostheses. During the past 3 years we have used homografts in approximately 400 cases for replacement of aortic segments which were excised for aneurysm or occlusive disease. In these cases both early and late results have been very satisfactory, particularly with lyophilized or freeze-dried grafts. Follow-up studies on many of these patients, including aortography, indicate that there is little tendency to dilatation in the grafts and the histologic appearance remains surprisingly normal for periods more than 3 years[8]. We have also used certain synthetic materials for aortic replacement. Aortic prostheses of orlon cloth, orlon knit and compressed Ivalon® polyvinyl sponge were used in 26 patients. In all but one of these patients where a thoracic replacement was done a bifurcation abdominal prosthesis was used. There were two late complications resulting from use of these synthetic materials. In one an orlon prosthesis eroded the duodenum several months later and in the other infection of an Ivalon® graft led to secondary hemorrhage 2 months later. These materials are somewhat more difficult to use in the aorta from a technical standpoint but may be recommended at present, particularly where homografts are not available.

RESULTS

During the approximate 5 year period included in this report excisional therapy for aortic aneurysms was employed in 253 patients with lesions of the abdominal aorta in 185 and thoracic aorta in 68, the types and location of the lesions indicated in figures 1 to 4. Death occurred within the first weeks of operation in 24 of the former and 23 of the latter with a total hospital mortality rate of 18 per cent. Several factors have been largely responsible for this apparently high operative risk. Perhaps the most obvious is the policy of accepting for operation almost all patients with aneurysm irrespective of advanced age or evidence of cardiac, renal or respiratory insufficiency. This is evident among the abdominal cases, for example, where approximately 30 per cent were more than 70 years old. Thus, in this elderly group fatality was almost double that of the younger patients. Moreover, the risk in hypertensive patients was twice that of the normotensive. Further indication of the significance of cardiovascular and renal disease is obtained from the fact that death in these patients usually was due to these causes.

Still another important factor contributing significantly to the mortality is the presence of rupture of the aneurysm, existing at the time of operation. Among the patients with abdominal aneurysm there were 25 with acute perforation, operation being performed as an emergency with the patients in shock with massive retroperitoneal hemorrhage. Although there were 9 deaths in this group, the salvage of 16 patients or 64 per cent is particularly striking. In spite of the risk of operation under these circumstances, resection of the aneurysm should always be attempted regardless of the apparent hopelessness of the situation. Moreover, operation should not be delayed in order to combat shock in such cases by massive transfusion and preparations should be made for immediate laparotomy. In most of these patients following the application of the proximal occluding clamp immediate improvement occurs and operation is remarkably well tolerated.

In the cases of thoracic aneurysm the operative risk is even higher than for the abdominal lesions. Undoubtedly, application of clamps to the thoracic aorta nearer its point of origin imposes greater strain upon the cardiovascular system in general and subjects the patient to the risk of more extensive injury from temporary interruption of circulation. For example, in this group of patients acute cardiac failure during the first 24 hours after surgery was the commonest cause of death. In aneurysms about the aortic arch and proximal descending aorta neurologic changes, including cord injury, and cerebral damage from ischemia or embolism were serious complications frequently resulting in death. It is significant that in fusiform aneurysms of this region (figs. 2 A-C) the mortality rate was 45 per cent in contrast to a mortality rate of 16 per cent in the distal thoracic aorta (fig. 2 D). In patients undergoing extensive bilateral thoracotomy respiratory complications were often severe requiring tracheostomy and artificial respiration to maintain life in some instances. Many of these patients had tracheobronchial compression and atelectasis at the time of operation.

Results of excisional therapy of dissecting aneurysms of the aorta were most gratifying in that survival and apparent cure of this grave condition were obtained in 10 out of 13 patients. The fact that virtually all of the 206 patients surviving operation were relieved of symptoms and returned to a relatively normal life strengthens our conviction that excisional therapy is the most effective method for aortic aneurysms. The serious nature of the disease itself dictates an increased risk in such operations, but with improvement in surgical technic and with further control of limiting factors still existing the risk of operation will undoubtedly be reduced.

SUMMARY

Aneurysm of the aorta is a serious disease causing distressing symptoms and usually leading to death within a year or 2 after diagnosis. Until recently surgery was unsatisfactory but during the past 5 years gratifying results have been obtained with excisional therapy.

For sacciform aneurysms tangential excision with lateral aortorrhaphy is effective whereas fusiform aneurysms require segmental aortectomy with res-

storation of aortic flow by aortic homograft or synthetic prosthesis. Results of treatment in 219 cases of the former and 37 of the latter are reported and factors influencing operative risk are considered.

Because of the unusual pathologic nature of dissecting aneurysm surgical therapy must be adapted to control the dissecting tendency. If the intimal tear occurs in the ascending aorta a re-entry passage is created in the descending aorta close to the origin of the ligamentum arteriosum. When the intimal tear occurs distal to ligamentum arteriosium this segment of aorta is resected, and a graft is inserted. In both types of operation after the aorta is divided the two layers in the lower segment are sutured together in order to eliminate the extension of the process distally. Results of treatment in 13 patients with dissecting aneurysm with 10 survivors are presented.

ADDENDUM

Recent analysis of patients operated through for aortic aseurysm reveal a total of 366 cases, 98 of which were thoracic and 268 abdominal. Since this report was submitted, aneurysms of the ascending aorta have been resected with segmental replacement by homograft in three cases utilizing the mechanical heart lung for cardiopulmonary by-pass. Temporary extracorporeal aortic by-pass, shunting blood from the left auricle to the abdominal aorta, was used successfully in 2 cases for resection of the descending thoracic aorta for aneurysm.

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THE CASE FOR HEMIGASTRECTOMY AND VAGOTOMY IN SURGICAL TREATMENT OF DUODENAL ULCER

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The objective of surgery for duodenal ulcer is to provide optimum eradication or cure of ulcer, maximum protection from recurrent ulceration with minimum morbidity produced by the operation. Great evidence is accumulating to show that hemigastrectomy with vagotomy best accomplishes this objective.

In order to rid the patient of the ulcer, protect him against a return and give the minimum nutritional and functional difficulties, several different procedures have been evaluated by various groups. After it was determined that three-fourth gastrectomy was the best measured type of subtotal gastrectomy to protect the patient against recurrent ulceration[13, 21, 23, 25, 26, 28, 36, 38, 39], it was found that nutritional and functional disabilities frequently followed the operation[2, 7, 14, 16, 24, 29, 31, 32, 37, 40, 41, 42, 44]. Its success at protection against marginal ulceration has, however, become the yardstick against which other substitution procedures must be measured. Even with this high degree of success, there still remained a small percentage of recurrent ulcerations reported by numerous investigators[16, 22, 24, 37, 40].

As early as 1929, Klein[20] reported 8 cases of duodenal ulcer with marked preoperative hyperacidity in which partial gastrectomy and anterior vagotomy produced anacidity. Subsequently Winkelstein and Berg[43] reported 26 cases with high preoperative acidity treated by partial gastrectomy and anterior vagotomy and then followed for 4 to 9 years at which time all patients were well.

Vagotomy alone was emphasized by Dragstedt[7] and others[13, 20, 31, 37, 40, 41] who followed his plan. It was soon found necessary to add a drainage procedure either as pyloroplasty or gastroenterostomy to overcome the stasis effect of the vagotomy. About 10 per cent is the average number of frank failures generally reported by various investigators after vagotomy and gastric drainage procedures[4, 5, 6, 7, 8, 12, 17, 19, 21, 33]. Grimson[14], however, reported only a 5 per cent recurrent rate of ulcers in 176 cases. Hoerr[17] after having been associated at the Cleveland Clinic with a group who had helped lead the way in popularizing vagotomy and gastroenterostomy, found with his colleagues that subdiaphragmatic vagotomy with posterior gastroenterostomy was not a completely satisfactory answer to the problem of peptic ulcer surgery. He stated that the rate of failures seemed too high. Therefore, in 1953, he and his colleagues changed the usual operation to hemigastrectomy and vagotomy, reserving gastroenterostomy and vagotomy for the poor-risk patient.

Numerous others, dissatisfied with their results and in search of a procedure which would offer the least operative disability and the least opportunity for recurrence, began to perform hemigastrectomy and vagotomy. Orr and Johnson[31], after having tried varying combinations of operations, recommended

hemigastrectomy and vagotomy and stated that there was a much lower postoperative morbidity and mortality with this type of ulcer surgery. Farmer and Smithwick[11] reported the cases of 40 patients after hemigastrectomy and vagotomy with achlorhydria occurring more frequently than after any other combination of procedures and a lower incidence of unpleasant postoperative side effects. Farmer[10] currently reports that he is very much impressed with the results of hemigastrectomy and vagotomy, after having followed some of the earlier cases for 9 years. He has observed no jejunal ulcer. For comparison with other procedures he quotes the following analysis:

Seventy-five per cent of patients with a posterior gastroenterostomy and a vagotomy have free postoperative acid.

One-third of the patients with a subtotal gastrectomy have free postoperative acid.

Twelve per cent of the patients with hemigastrectomy and vagotomy have free acid. It has been found that of this latter 34 per cent there is some evidence of incompleteness of vagotomy in each case according to the insulin test. It also is found that the amount of acid put out by these people is far less than is found in patients who have free acid after subtotal gastrectomy or after posterior gastroenterostomy and vagotomy. It is the general impression from his group that there is a definite relationship between the size of the gastric remnant and the degree of postgastrectomy symptoms that the patients have.

Edwards in 1954[9] reported 150 cases of vagotomy and antrectomy who had shown results superior to either gastroenterostomy and vagotomy or subtotal gastrectomy. From the same institution with Edwards, Scott[34] reported that at Vanderbilt in the past 8 years, over 300 hemigastrectomies and vagotomies have been performed with no marginal ulcers seen to date. The current impression there is that there are no gastric cripples.

Coffey and Lazaro[3] described 55 cases of hemigastrectomy and vagotomy with a Finey-VonHaberer anastomosis in which there was no postoperative free acid found in 53 of the patients. One patient had postoperative free acid, and developed recurrent duodenal ulcer and bleeding. At reoperation that patient was found to have had an intact right vagal trunk.

In 1951, the author and his associates at the Veterans Administration Hospital, Atlanta, Georgia, began a series of hemigastrectomy and vagotomy for duodenal ulcer and in 1953 reported the preliminary observations[2]. Detailed follow-up data on the first 30 patients followed for an average time of 19.9 months showed only 1 patient who had any free acid, and this was very minimal. (This patient had shown a very high preoperative free acid). No patient had difficulty in maintaining an adequate weight level. There had been no patient who had any clinical or other evidence of recurrent ulceration. In 1953, the author entered the armed forces, but the series of operations has been continued. Thoroughman[35] from the same institution in a recent communication reported that after 180 operations, the following advantages seem apparent:

The operation is technically easier to do than a subtotal gastrectomy. The anastomosis can be brought up almost to the skin level.

There are no marginal ulcers to date.

There is a definite lesser incidence of small stomach ulcer syndrome.

There is about the same incidence of dumpers.

Nutritional problems are fewer.

One patient had pronounced ileus after vagotomy and required the urecholine for 2–3 weeks, but entirely cleared subsequently. Two patients had considerable postoperative diarrhea, which was not incapacitating.

DISCUSSION

The abnormal physiology associated with development of peptic ulcer and producing auto digestion of duodenal or gastric mucosa is related to an excessive acid-peptic factor and the ability of the mucosa to withstand digestion itself. The aim of the various operations has been to reduce the acid-peptic factor. Since pepsin is inactive at a ph level greater than 4.5 to 5.0, aims have been to reduce the production of acid.

The acid is produced by the oxyntic cells located sparsely in the fundus and primarily in the body of the stomach. Pepsin is produced by zymogen cells in the same location. Gastric lipase and renin or very weak hormones produced in the stomach are not guilty of contributing significantly to the ulceration. Mucin is secreted by cells in the pylorus and cardia and mucous neck cells in the fundus. This mucous has a ph of 7 to 7.5 has acid combining powers and inhibits peptic activity. It has been found that vagal stimulation primarily gives an increase in the production of pepsin, but also has some lesser effect in the production of acid. Histamine has little effect on the production of pepsin, but produces a great increase in the amount of acid secreted.

The secretions of acid and pepsin are produced according to the following influences:

1. Base line secretion of the individual person without other influences. This is extremely variable and high basal values may account for the few failures to prevent recurrent peptic ulcer after protective measures have been carried out.
2. Gastrin is a hormone produced in the antrum that stimulates the oxyntic cells of the fundus and body of the stomach to produce acid. There is some conjecture as to whether this is identical to histamine.
3. The vagus nerve produces an increase in the activity of the cells to secrete acid and pepsin. This is a direct transmission from the central nervous system and varies directly with a degree of mental and emotional tension present.

We have the problem of excessive acid production by oxyntic cells and pepsin production by the zymogen cells, both of which are located in the fundus and body of the stomach. Some increase in mucin production would help to neutralize the acid and protect the mucosa from pepsin digestion. An elevated ph would also prevent the activity of the pepsin. In order to decrease production of acid and pepsin, stimuli to excessive production may be removed and/or the source of production may be decreased.

Subtotal gastrectomy as originally practiced was in the neighborhood of a 50 per cent resection, and was designed to remove the hormonal factor of pro-

ducing acid. It was found, however, that too many recurrences developed after this and accordingly the extent of the subtotal gastrectomy was increased until the level of three-fourths or greater was found to be that which produced postoperative achlorhydria. This was accomplished by removal as mentioned above of the hormonal source or secretion, as well as a partial removal of the cells that actually produce acid and pepsin.

Vagotomy simply removes the cephalic source of stimulus. The completeness of the vagotomy is not 100 per cent in all cases. Hollander's insulin test to produce hyperacidity after hypoglycemia has been the most widely accepted test for the completeness of vagotomy. Yet, there is some question as to how accurate this test is. It certainly does not measure the pepsin production of the stomach (pepsin production is the chief result of vagal stimulation). There are numerous examples of insulin tests that have indicated an incomplete vagotomy, when the clinical appearance and results showed no further acid peptic erosion. As time goes by, operators are becoming more adept at getting rid of all vagal fibers, and perhaps failures in vagotomy are becoming less frequent.

There has been some experimental work to indicate that the combination of removal of both the hormonal factor by 50 per cent gastrectomy and the cephalic stimulation by vagotomy is the ideal approach to the solution. Howe and Porell[18] reported that in dogs with 50 per cent gastrectomy and vagotomy the ph of the stomach remained above the critical acid level of 4.5 during fasting, after broth stimulation and after histamine and insulin stimulation. There was an occasional slight acid response after histamine. This response compared favorably with that found in dogs having an 80 per cent gastrectomy. Oliver[30] showed that while three-fourth gastrectomy did not protect dogs from a Mann-Williamson ulcer, one-third to three-fourths gastrectomy with vagotomy did protect the dog from such ulceration. Transposing the investigations to the human being, Howe and Porell[18] found that in 6 patients who had one-third gastrectomy and vagotomy the ph levels in fasting and after other stimuli reached dangerous levels, but in 18 patients with a 50 per cent resection and vagotomy the acid studies were comparable with a three-fourth gastrectomy.

CONCLUSIONS

The removal of the hormonal influence for production of acid by the stomach and the removal of the cephalic influence for production of the acid and pepsin are both accomplished by the operation of hemigastrectomy and vagotomy.

This combination has produced both experimentally and clinically in the hands of numerous investigators achlorhydria postoperatively. The protection seems even greater than a 75 per cent gastrectomy. In 778 cases reported by various investigators,[3, 11, 17, 34, 35] only one recurrent ulcer has been found, and in this patient an intact right vagus nerve was found at reoperation.

As more experience in the technic of vagotomy has been obtained, the incomplete vagotomies become very rare indeed.

Postoperative nutrition has not been a problem in hemigastrectomy and vagotomy.

Dumping syndrome has a direct proportion to the size of the gastric remnant, and although occasional dumping is seen it is less frequent after the less radical gastrectomy with vagotomy than after a more radical gastrectomy.

The other symptoms of a small stomach (inability to eat a full size meal, postprandial fullness, nausea and vomiting) are much less frequent after hemigastrectomy and vagotomy than after a more radical operation.

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Winston-Salem N. C.

EXPERIENCE IN THE SURGICAL MANAGEMENT OF ATRIAL SEPTAL DEFECT AND PULMONIC STENOSIS UNDER HYPOTHERMIA

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The recent application of hypothermia technic during the operative care of selected patients has met with rather phenomenal success in many hospitals throughout the world. Hypothermia employed as an anesthetic adjunct and metabolic depressant was first applied successfully in a clinical case in September 2, 1952 by Lewis and Taufic[6] during the closure of an interatrial septal defect. The more recent clinical success in by-passing the heart and lungs employing a mechanical pump and *"bubble"* oxygenator as has been demonstrated repeatedly by Lillehei, Varco, and associates[8] will no doubt limit the application of hypothermia to some extent, but will not entirely supplant cooling as an aid to the anesthesiologist and surgeon when confronted with some types of cardiovascular, general surgical and neurosurgical problems in which general body cooling of patients has been employed with encouraging degrees of success; e.g., rapidly performed open heart surgery during inflow and outflow occlusion; in isolated instances during operative attack on lesion of great vessels, and occasionally during the operative extirpation of neurogenic and hepatic tumors.

The direct visual and operative approach to any remedial defect or lesion is, in most hands, the method of choice for achieving the best results, provided the risk of obtaining such visualization and exposure is not unduly hazardous. It is our present belief that the simple type of atrial septal defect (ostium secundum) and isolated pulmonic stenosis, valvular or infundibular, can be most satisfactorily corrected by direct exposure under anesthesia modified by hypothermia. We wish to report on our experience in the surgical management of a small series of patients with such congenital cardiac lesions.

Atrial Septal Defects: Atrial septal defect has in recent years been diagnosed rather frequently and is considered by most cardiologists and pediatricians as the commonest single congenital heart lesion, although Lillehei[7] is of the considered opinion that ventricular septal defects, alone or associated with other anomalies of the heart or great vessels, as not uncommonly seen, probably exist more often than atrial septal defects.

From June 1953 to November 1955, 12 patients ranging in age from 21 months to 39 years had cardiotomy performed under hypothermia for repair of atrial septal defect by the direct method at Fitzsimons Army Hospital.

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Symptomatology: A generalization has been offered by Blount[2] in regard to this category of congenital heart disease; he has stated as follows:

> "In patients above the age of 2 years, the diagnosis on clinical grounds alone is relatively easy. The diagnosis in infancy is an entirely different story. The history is of little help in the diagnosis. It is the history of any patient with a left to right shunt, and, depending upon the volume of the shunt, the symptomatology will vary."

Retarded growth, poor exercise tolerance (dyspnea without cyanosis), and frequent respiratory infections were the most common symptoms in our group of patients (table I).

Physical Findings: Evidence of physical underdevelopment was present in most of our patients, but no definite mental retardation was apparent. Bulging or undue prominence of the left anterior chest wall with heaving pulsations in this region were noted in half the patients. A thrill or shock occasionally was palpable in the pulmonic area. The heart usually was enlarged to percussion and roentgenographic examination, and a grade II, low-pitched systolic murmur was most prominent in the second left intercostal space at the left border of

TABLE I

Predominant symptoms

(12 patients with atrial septal defects)

	Patients	Per cent
Mild to severe exertional dyspnea	10	84
Retarded growth (underdeveloped)	8	66
Frequent respiratory infections	6	50
No definite symptoms	2	
Vague, indefinite (apparently unrelated symptoms), however, patient had been given digitalis	1	
Cardiac decompensation prior to hospitalization	1	

TABLE II

Common physical findings

(12 patients with atrial septal defects)

	Patients
Parasternal systolic murmur (grade II, low-pitch) best heard:	
Left second intercostal space	10
Left third intercostal space	1
Left fourth intercostal space	1
Associated diastolic murmur, low-pitched, blowing	3
P_2 greater than A_2	7
Definite physical retardation	7
Prominent left anterior chest wall (overactive cardiac pulsations)	6
Shock and/or thrill pulmonic area	5

the sternum; the second heart sound frequently was somewhat increased and widely reduplicated at this site; a blowing pulmonic diastolic murmur occasionally was heard. A soft early diastolic murmur at the mitral area often was heard. The systemic blood pressure was not remarkable.

Roentgenographic Findings: Fluoroscopic study usually revealed an increased vascularity of the lung fields, slight to moderate enlargement of the heart and an increase in size and amplitude of pulsation of the pulmonary artery. The right atrium often appeared vertically elongated. Expansile pulsation of hilar arteries was often seen. Roentgenograms always corroborated the fluoroscopic findings with cardiac silhouette suggesting right atrial, right ventricular and pulmonary artery enlargement. Pulmonary vascular markings were increased above normal in 10 of the 12 patients.

Electrocardiograms: Ten of the 12 patients showed a pattern of incomplete right bundle branch block on electrocardiographic tracings—a finding suggesting diastolic overloading of the right ventricle (dilatation and hypertrophy). One patient had complete right bundle branch block and one 6 year old boy had a relatively normal electrocardiogram.

Cardiac Catheterization Findings: All patients had preoperative cardiac catheterization. In most instances there was slight to moderate increase in pressures above normal in the right atrium, right ventricle and pulmonary artery. Pressure readings in millimeters of Hg in a rather typical case were as follows: Right atrium—11/5; right ventricle—42/0; pulmonary artery—44/13. Two patients had pulmonary hypertension exceeding 100 mm. Hg. All blood samples from right atria gave significantly high oxygen saturations when compared with mixed venous blood, as would be expected in left to right shunts at the atrial level. Flow ratios of pulmonic to systemic circulation ranged from 1.7:1 to 4:1. On cardiac catheterization studies, one patient was demonstrated to have, in addition to atrial septal defect, anomalous pulmonary veins entering the right atrium; the catheter entered the right atrium by way of a left superior vena cava. This patient's congenital defects did not lend themselves favorably to operative correction as will be mentioned later when considering the complications or difficulties occurring at surgery.

Technical Considerations: In general we have adhered to the cooling methods and technics of Swan and his associates,[13] and are highly indebted to him for his aid and assistance during the early clinical application of hypothermia at Fitzsimons Army Hospital.

Anesthesia: Induction as a rule is accomplished with intravenous pentothal and maintained with oxygen-ether mixture after endotracheal intubation and a relaxant to prevent shivering; after desired level of cooling is obtained the patient is maintained on 100 per cent oxygen administration. A recording thermometer is placed in the rectum and electrocardiographic electrodes are attached to the extremities and connected to a cardioscope and direct writer electrocardiographic apparatus.

Cooling Method: The patient is gently placed in a tub of ice water with temperature ranging from 2–6 C. after he is sufficiently anesthetized to prevent

shivering. A surgical team is immediately available at all times should ventricular fibrillation or cardiac arrest occur. A cardiologist is always present to observe the cardioscope and to serve in a consultatory capacity throughout the operative procedure. When the rectal temperature reaches 31–29 C., the patient is placed on a rubber mattress through which water of variable controlled temperature can be circulated. The cooling period usually parallels the size of the patient; the immersion time in this group of patients varied from 14 to 70 minutes —average period being 38 minutes. Temperatures always continue to drop after the patient is removed from the ice-water bath, and can be expected to drift downward an additional 3–5 C.; drifts beyond this might be expected in an occasional patient if not prevented by increase in the temperature of the water circulating in the rubber mattress on the operating table. Body temperatures ranged from 23–28 C. at the time of cardiotomy in our patients—the average being 25–27 C. which is the temperature range considered optimum for the performance of cardiotomy with inflow-outflow occlusions for periods lasting 3–8 minutes. Under hypothermia the patient's carotid pulsations are difficult to obtain or barely palpable and blood pressure is unobtainable.

Operative Procedure: Bilateral anterolateral thoracotomy is performed with division of the body of the sternum in a staggered fashion, to facilitate reapproximation, this gives adequate exposure of the heart and mediastinal structures. Usually the pleural spaces are entered through the third intercostal space on the right and the fourth on the left. The pericardium is opened widely by means of a "T" shaped incision with care not to damage the phrenic nerves; bleeding points at the severed edges of the pericardium are carefully controlled as are all areas throughout the procedure with fine silk or cotton ties. The heart is thoroughly inspected and gently palpated to confirm the clinical diagnosis. An attempt is made to delineate the size and position of the interatrial septal defect by invaginating and palpating through the lateral wall of the dilated right atrium. Other anomalies such as aberrant pulmonary veins, anomalous left superior vena cava, etc., are visualized and evaluated if present. The venae cavae are then isolated near the right atrium the superior proximal to the azygos vein, and encircled with heavy cotton tape ligatures to provide the inflow occlusion during open cardiotomy.

Traction sutures are placed on the lateral wall of the right atrium to facilitate elevation for placement of a noncrushing Satinsky or Harken clamp to the atrial wall. A 3–4 cm. atriotomy incision is made in the wall isolated by the noncrushing clamp. The patient is then hyperventilated with 100 per cent oxygen for a period of 5 minutes to decrease general body carbon dioxide concentration. This creates a temporary respiratory alkalosis, as advocated by Swan[14] and Scott[10] for possible prevention of troublesome arrhythmias, including ventricular fibrillation. Right atrial blood samples taken immediately after this period of hyperventilation have varied from pH of 7.65 to 7.75. After occlusion of inflow channels with previously placed cotton tapes, a noncrushing clamp is placed through the transverse sinus at the base of the heart and closed over the pulmonary artery and aorta. It is so placed that the aorta is occluded proximal

to coronary ostia in order to prevent subsequent ingress of air into the coronary system. We do not occlude the pulmonary vessels at the root of the lungs as the amount of blood returning to the heart from this source after pulmonary artery occlusion has not been troublesome during septal defect closure. After removal of the atrial clamp, the septal defect is visualized as blood is aspirated from the atrial compartments. A hasty digital exploration is made of the communicating atrial chambers and the mitral valve is evaluated to determine if there be any stenosis. The septal defect is again inspected to determine if it is the common secundum or the rare and more complicated and serious ostium primum type; again from the interior view of the atria the operator must determine if anomalous pulmonary veins exist.

The defect or multiple defects (cribiform type) initially were closed with interrupted figure of 8, no. 000 silk suture. Our last six defects have been closed, however, with a running silk or cotton suture—one interrupted suture is placed at the superior angle or edge of the defect and after slight upward traction on this suture the continuous suture is started at the inferior angle and continued upward. Before tying this suture to the previously placed interrupted suture, the air is displaced from the left atrium by injecting saline solution through the incompletely closed defect employing a bulb syringe. Septal closure is performed meticulously to insure the patency of the ostia of the venae cavae and to avoid diverting either venous stream into the left atrium. Suture should not be placed in the anatomic location of the atrioventricular node and neither should the patency of the coronary sinus be compromised. If anomalous pulmonary veins exist, the septal closure should be so constructed as to divert this pulmonary venous flow into the left atrial compartment. The right atrial chamber then is filled with saline solution or Ringer's solution and the noncrushing clamp applied proximal to the cardiotomy incision. The superior vena cava, aorta and pulmonary artery are quickly released and the atrial incision is closed by appropriate running suture on an atraumatic needle. It has been our policy to begin gradual release of the tape occluding the inferior vena cava 2 minutes after release of the superior vena cava; this measure was adopted to prevent rapid return of accumulated epinephrine to the heart chambers and thus possibly to decrease the likelihood of ventricular fibrillation. Recent report of animal experiments under hypothermia by Shumway and Lewis[11] indicating the apparent value of epinephrine to the hypothermic heart of normal dogs would seem to negate our theory regarding this possible relationship of epinephrine to ventricular fibrillation. However, we will continue to gradually release the occluded inferior vena cava to prevent sudden cardiac overdistention after correction of the congenital defect. The pericardium is loosely closed after the heart resumes a forceful beat. On 3 occasions hearts did not tolerate this pericardial reapproximation well; 2 became visibly cyanotic and troublesome arrhythmias developed; the third heart developed a complete heart block at this stage of the procedure; all 3 hearts returned to normal color and began to beat normally after release of pericardial sutures. In each instance the pericardium was more completely opened to the diaphragmatic angle and no sutures were reapplied; all 3 patients convalesced uneventfully.

Closure of the chest incision is accomplished by use of fine interrupted non-absorbable sutures after establishment of adequate pleural drainage into under water seal bottles; approximation of sternal edges is maintained with crossed stainless steel sutures. In adults a bone peg is removed from a rib and inserted into adjoining sternal marrow spaces to contribute to sternal stability and bony union.

Rewarming Patients: In our more recent cases, we have placed our patients in a warm water bath, temperature 42–44 C., for rewarming. The first 8 patients were rewarmed after cardiotomy closure by means of diathermy coils previously placed about the abdomen and pelvis. In addition, the pleural spaces were irrigated repeatedly with warm saline solution, temperature 40 C. In our hands, the warm pleural irrigation method has not been very effective and 2 patients received significant superficial burns as the result of the diathermy application; in addition, it is our opinion that those patients who had diathermy warming experienced more troublesome gastric distention and ileus than those in whom the warm water bath method was employed. No wound infections have occurred in this group of patients.

Cardiac Drug Application: We have not recently employed prostigmine as recommended by Swan[12] since we have not been fully convinced of the merits of this agent, which he injects into the proximal portion of the temporarily clamped aorta prior to inflow and outflow occlusion. Swan and co-workers, as well as Davis and Peabody,[3] are convinced that the coronary perfusion of this drug makes the cold heart less susceptible to ventricular fibrillation; they continue to report encouraging results after its use although Lewis and associates[5] apparently have as favorable clinical results without employing prostigmine. Six of our patients had the coronary system perfused with prostigmine solution and 6 did not—3 patients in this latter group had sino-auricular node and auricular wall blockade with 1 per cent procaine solution as has been advocated by Shumacker and associates,[9] and 3 had neither prostigmine nor procaine injection.

In the prostigmine-treated group, one patient developed complete heart block as the pericardium was being closed—the heart reverted to normal rhythm after the pericardial sac was widely opened. The heart of a 39 year old patient developed ventricular fibrillation early and prior to opening the pericardium (during procedure had neither prostigmine nor procaine blockade). The heart reverted to a standstill and finally to a normal rhythm after cardiac massage and injection of 4 cc. of potassium chloride solution (8 mEq) into the right ventricular chamber. This patient withstood the remainder of the septal closure well, having only auricular fibrillation which occurred at some time during operative procedures in all of our patients. One of the 3 patients who had sino-auricular nodal blockade developed ventricular fibrillation during septal repair. The chemical defibrillator (KCl solution) did not convert the heart to standstill; however, one electric shock, $\frac{1}{10}$ second at 120 volts, gave immediate arrest and spontaneous return to a regular rhythm.

Pulmonic stenosis: Over a 2 year period, June 1953 to June 1955, 6 patients varying in age from 20 months to 23 years and suffering from valvular or infundibular pulmonic stenosis had surgical correction of these congenital defects

TABLE III

Complications and/or unusual findings at surgery
(12 patients with atrial septal defects)

	Patients	Per cent
Atrial fibrillation during procedure	12	100
Ventricular fibrillation	2	17
Diathermy burn	2	17
* Large, almost common atria, left superior vena cava, anomalous pulmonary veins and marked stenosis mitral valve	1	
Anomalous right pulmonary veins opening into right atrial compartment	1	
Septum incompletely closed elsewhere—plastic button retained	1	

* This 21 year old woman had marked disability due to lowered cardiac reserve. After finger fracture of the congenitally stenotic mitral valve, temporary digital pressure occlusion of septal defect caused marked cyanosis of face and upper extremities and venous pressure of over 400 mm. water; therefore, only approximately 50 per cent closure of the interatrial defect was attempted. The patient convalesced without undue complications—has since become pregnant and given birth to a normal child.

TABLE IV

Surgical data

Total inflow-outflow occlusion periods	2 minutes, 45 seconds to 6 minutes, 5 seconds *(Average 4 minutes, 42 seconds)*
Total operating time	2 hours, 15 minutes to 5 hours, 15 minutes *(Average 3 hours, 10 minutes)*
Duration of ventricular fibrillation	15 minutes and 4 plus minutes

(Two patients—both convalesced uneventfully)

TABLE V

Postoperative complications

	Patients	Per cent
Gastric distention and paralytic ileus (Controlled by nasogastric suction)	4	33
Pulmonary congestion and atelectasis (One patient required emergency tracheotomy)	4	33
Severe tachycardia	2	17
Partial median and ulnar nerve paralysis	1	8.3
* Failure to completely close defect (Postoperative cardiac catheterization confirmed)	1	8.3
Death—40 hours after closure of septum—multiple pulmonary emboli	1	8.3

* Small residual septal defect closed at subsequent operation.

under acutely induced hypothermia. Two of these patients had small interventricular defects in addition to pulmonary stenosis.

Electrocardiograms: Electrocardiographic studies on all 6 patients presented conclusive evidence of marked right ventricular hypertrophy.

Technical Aspects: Methods used to obtain anesthesia and hypothermia were similar to those employed for the atrial septal group of patients. Bilateral thoracic sternal transecting incisions were made, entering the pleural spaces through the fourth intercostal space on the right side and the third on the left. The pericardium was opened widely over the right ventricle and the pulmonary artery. This myocardial exposure permits the operator to evaluate the right ventricular outflow tract for visual and palpable evidence of an infundibular stenosis. After tape ligatures are placed about the venae cavae, for subsequent inflow occlusion, the anterior surface of the proximal 3–4 cm. of the pulmonary artery which in most instances showed some degree of poststenotic dilatation is cleared of its adventitia. Traction sutures are placed in the wall of this artery and a curved or spoon Pott's ductus clamp is applied in a tangential fashion so as to only partially obstruct the pulmonary blood flow. An arterotomy 2.5–3 cm. long then

TABLE VI

Predominant symptomatology

(4 patients)

	Patients	Per cent
Exertional dyspnea (exercise tolerance reduced significantly)	4	100
Mental and/or physical retardation	4	100
Frequent pulmonary infections	2	50
Convulsive episodes	1	25
Periods of syncope	1	25
Repeated episodes of congestive failure	1	25
Cyanosis—chronic or after exertion	0	
Squatting when fatigued	0	

TABLE VII

Common physical findings

(6 Patients)

	Patients	Per cent
Harsh systolic murmur grade III–V over precordium, best heard over left second or third intercostal space	6	100
Chest prominence near left sternal border	6	100
Pulmonic second heart sound pure—not split	5	83
Definite cardiac enlargement	5	83
Systolic thrill pulmonic area	4	66
Definite mental and/or physical retardation	4	66
Diminished second pulmonic sound (case of infundibular stenosis)	1	17

TABLE VIII

Roentgenographic Findings

(6 patients)

	Patients	Per cent
Normal pulmonary vascular markings	5	83
Enlargement of heart		
Boot-shaped heart (enlarged to left with elevation of apex)	3	83
Generalized enlargement of cardiac silhouette	2	
Pulmonic area prominent with increased pulsation suggesting poststenotic dilatation	5	83
Pulsating hilar vessels	0	

TABLE IX

Catheterization Findings and Interpretations

(6 Patients)

	Right Atrial Pressure	Right Ventricular Pressure (MM. Hg)	Pulmonary Artery Pressure	Periph. Arterial Saturation	Remarks
L.A., Male, 3 yrs., 8 mos.	12/4*	160/10	—	96%	Catheter passed through a patent foramen ovale—no functioning opening thought to exist; no evidence of infundibular stenosis
M.Y., Female, 23 yrs.	10/2*	147/8	26/9 to 23/10	94%	Considered to have pure pulmonic valvular stenosis.
S.W., Male, 21 mos.	8/−4*	116/0	—	97%	Considered to have pure pulmonic valvular stenosis.
M.A.O., Female, 3 yrs.	17/5*	87/5 to 109/6	—		Considered to have pure pulmonic valvular stenosis.
J.D., Male, 20 mos.	10/4*	72/14	16/10	72%	Valvular pulmonic stenosis, I.V. septal defect.
H.I.D., Female, 20 yrs.	4/0	119/0	29/4	86%	Also small interventricular septal defect.

* Giant "A" waves recorded on RA pressure curve.

is made in this portion of the artery and the patient is hyperventilated for 5 minutes prior to inflow occlusion and perfusion of the coronary system with prostigmine solution which was employed in 5 of the 6 patients. The distal portion of the main pulmonary artery is quickly occluded with a noncrushing clamp and the Pott's clamp removed (occlusion of aorta not necessary if isolated pulmonic stenosis). An aspirating tip is employed to allow visualization of the conical (funnel type) or diaphragmatic stenotic valve which is grasped with forceps and opened widely to the annulus in a transverse fashion to provide a

bicuspid valve. The infundibular region then is exposed by spreading a Kelley clamp in the right ventricular outflow area or by insertion of the small finger of the operator. No evidence of infundibular stenosis was found in 5 patients. One had pure infundibular stenosis which was detected on opening the pericardium. Cardiotomy was performed over the infundibular region and the infundibular wall was bitten away with punch forceps.

After intracardiac filling on release of occluding clamps and tapes and reapplication of the curved Pott's clamp to the incised artery are accomplished, the incision in pulmonary artery is closed with a running suture of arterial silk.

The hypothermic temperatures attained and methods of rewarming were comparable to those employed in the atrial septal defect series. Estimated blood loss was replaced taking care not to over-transfuse the patients.

Cardiac inflow and outflow occlusion periods ranged from 2 minutes and 10 seconds to 4 minutes in this series of patients subjected to surgical correction of right ventricular outflow obstruction—periods slightly less than the necessary occlusion periods in the septal defect group.

Complications at Surgery: Auricular fibrillation occurred at some time during heart exposure in 2 patients; no arrhythmia was present at the completion of surgical procedure and both patients convalesced uneventfully. One 21 month old patient had a minor convulsion during anesthesia induction prior to immersion cooling; pulmonic valvulotomy was accomplished without difficulty, but the patient died 22 hours later as detailed below.

Postoperative Complications: No noteworthy or significant complications occurred in 3 patients. One patient, a 20 year old white woman, suffered a cerebrovascular episode on the eighth postoperative day which was manifested by partial paralysis of the right side of the face, the right arm and right leg. The patient subsequently recovered without any apparent sequelae. One 20 month old male, whose temperature was reduced to 30 C. at surgery, did well postoperatively and was discharged on the twelfth postoperative day. On the sixteenth postoperative day "*knotty lumps*" were noted in the skin and subcutaneous tissues over the buttocks and abdominal panniculus. The patient was readmitted and a biopsy confirmed the diagnosis of subcutaneous fat necrosis. Over the course of several weeks the lesions showed progressive involution. This case has recently been reported by Blake, and associates[1]. One 21 month old male died on the first postoperative day. His temperature returned to a normal level shortly after operation; however, 6 hours later the temperature dropped to 95 F., respirations became shallow, and moderate cyanosis developed in spite of the use of oxygen by nasal catheter and oxygen tent. After rewarming the patient on a rubber mattress spasticity of his extremities and a few convulsive episodes were noted. A tracheotomy was performed in hopes of improving the obvious cerebral anoxia. The child died shortly thereafter.

Results to Date: All 5 patients have done well clinically; good to excellent improvement in symptoms have been noted. Cardiac murmurs are still present but much less harsh than before valvulotomy; a faint systolic thrill is palpable at the pulmonic area on 2 patients.

DISCUSSION

With repeated reports of acceptable mortality rates from surgical centers performing cardiac surgery with the aid of hypothermia, we are of the opinion that most cases of atrial septal defect of the ostium secundum type and cases of pure pulmonic valvular or infundibular stenosis should be corrected by direct surgical approach with good visualization in a relatively bloodless field. We believe that one would be unlikely to obtain complete closure by blind or indirect methods in the "*cribiform type*" of atrial septal defect as demonstrated in one of our patients who had 7 to 8 ostia scattered over the atrial septal membrane. More recently we have closed septal defects on a patient who had a large secundum type and two small openings 4–5 mm. in diameter which were situated in the rim structure of the incomplete septum; it is likely that such accessory openings would be left unclosed when indirect or blind technics are employed. Since changing our technic to the continuous suture method of closure of septal defects we have observed no evidence of incomplete closures as was experienced in an early case whose defect was closed with interrrupted sutures. This 7 year old boy has subsequently been reoperated upon and cured.

Perfusion of oxygenated blood through the coronary system during cardiotomy under hypothermia is presently being conducted experimentally by Lewis and associates[5] for the prolongation of the "*safe period*" of inflow-outflow occlusion. In clinical cases as demonstrated with impressive success by Grow and associates,[4] this approach seems very encouraging and will no doubt extend the indications for hypothermia methods to more complicated congenital and acquired cardiac lesions.

SUMMARY

Eighteen patients, ranging in age from 20 months to 39 years, have had simple direct vision cardiotomy or arteriotomy approaches for the correction of atrial septal defects or for the relief of isolated pulmonic or infundibular stenosis with the aid of acutely induced general hypothermia. Sixteen of these patients are living and follow-up studies and reports indicate that 10 who had repair of interatrial septal defects are cured and one (with additional cardiovascular defects) markedly improved. The 5 patients who had surgical relief of pulmonic stenosis have had significant to striking relief of symptoms. Three patients have been followed for over 2½ years. Two patients, one in each congenital category, failed to recover after tolerating the hypothermia and surgical procedure well. One, an adult with interatrial septal defect, developed multiple pulmonary emboli on the first postoperative day, and the other, a 21 month old infant with pure pulmonic stenosis, died approximately 20 hours after valvuloplasty from uncontrollable peripheral circulatory collapse and cerebral anoxia.

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NEUROSURGICAL ALLEVIATION OF PARKINSONISM

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Since 1817 when James Parkinson described the syndrome of the shaking palsy which bears his name, there has been a sustained interest in developing new methods of therapy for this affliction. This interest has, thus far, resulted in very little concrete progress toward the development of a specific medicinal agent which will either eliminate the disabling symptoms of parkinsonism or halt its inexorable course, once the first sign of the shaking palsy has made its appearance. Thus, in our present state of knowledge, the progress of parkinsonian tremor and rigidity and gait abnormalities, as well as the other stigmas of parkinsonism, usually is relentless and inevitable. The average patient usually will reach a lingering stage of almost total helplessness; speechless, expressionless, unable to move at will but constantly shaking from involuntary tremor, and held in a prison of his own rigid musculature.

It is this invariably pessimistic prognosis that has led some patients to submit to brain surgery in the hope of a degree of alleviation from their symptoms, and has led some neurosurgeons to attempt procedures for such alleviation. It is the purpose of this discussion to review briefly the procedures which have been attempted by neurosurgeons up to the present time and to describe specifically two original technics which have been employed in a series of 145 patients, on our own service. It is my opinion that neurosurgical therapy has reached a stage where it may be considered a reasonably safe, practical, and useful tool for the treatment of many cases of parkinsonism. I would like to present some of the results of such treatment.

REVIEW OF NEUROSURGICAL APPROACHES TO PARKINSONISM

The Pyramidal Tract Operations: During the past 2 decades, neurosurgeons have devised operations at virtually every level of the nervous system during their attempts to alleviate some of the tedious symptoms of parkinsonism. Most of the early efforts consisted of destructive lesions of the pyramidal tract. Neurosurgical operations of the cerebral cortex for involuntary movements were originated by Horsley, who excised the precentral cortex in cases of athetosis as early as 1890[12]. Operations which were devised to resect either the premotor cerebral cortex (area 6) or motor cerebral cortex (area 4) were introduced by Klemme and by Bucy, approximately 20 years ago.[2, 13] Bucy stated that cortical extirpation is most effective when it includes cortical area 4 and 6 of Brodman. This operation produces a contralateral hemiplegia which subsequently lessens

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in severity leaving the patient with a residual hemiparesis but without tremor. Epiletiform seizures may develop following this operation. Rigidity and incapacitation are not decreased and may, in fact, be increased by cortical extirpation.

As a result of his investigation Bucy stated, "Nothing in my experience leads me to believe that it is possible to abolish tremor by any procedure which does not interrupt the pyramidal tract or destroy that portion of it which arises from the precentral gyrus." This conclusion stimulated others to attack the pyramidal tract at levels below the cortex. Putnam[17] devised the operation of pyramidotomy which consists of incision of the pyramidal tract at the level of the second cervical segment of the spinal cord. Ebin[9] and Oliver[16] have devised modifications of spinal pyramidotomy. Walker[19] has devised an operation upon the pyramidal tract in the cervical peduncle. This operation is referred to as pedunculotomy. According to Walker, a compromise with paralysis and freedom from tremor is the best that can be expected from pedunculotomy or from other operations aimed at the pyramidal tract, either at the cortical or spinal cord level. Such operations were devised solely to relieve tremor and they suceed in this aim only at the expense of motor power. It has since been demonstrated that tremor can be relieved without necessarily sacrificing motor power. Thus, there is rarely, if ever, at the present time, any indication for purposeful destruction of the pyramidal tract in the treatment of parkinsonism.

Basal Ganglia Operations: A more profitable neurosurgical target in cases of shaking palsy is the region of the basal ganglia. A major advance in the surgical therapy of parkinsonism was the investigation of Meyers in the surgery of the basal ganglia. Since 1940, Meyers[14] has experimented with various operations among which are: (1) extirpation of the head of the caudate nucleus and interruption of fibers in the oral portion of the anterior limb of the internal capsule. (2) extirpation of the head of the caudate nucleus and the oral one-third of the globus pallidus and putamen, and (3) section of the pallidofugal fibers emerging from the mesial globus pallidus. Meyers has said that "for each of these procedures, it has been possible to demonstrate an obvious improvement with respect to tremor and rigidity". He considers pallidofugal section the most effective of these three operations. Meyers' experience convinced him that the risks are too great to warrant the general use of transventricular operations in parkinsonism. However, even though Meyers does not recommend his transventricular operation for general use in neurosurgical clinics, his work introduced new concepts into the surgery of parkinsonism.

Browder[1] has developed a modification of Meyers' transventricular operation which he calls the capsular operation. This operation reduces tremor and also to some extent rigidity. Although it initially produces a paralysis of the extremities, Browder stated that the paralysis largely disappears although the patient subsequently "shows a lack of interest in using the hand". Browder concluded that fully 90 per cent of patients with parkinsonism are excluded as candidates for this procedure.

In recent years, other basal ganglia operations have been devised. Spiegel and

Wycis[18] have produced electrolytic lesions in the pallidofugal fibers by employing a stereotactic apparatus which they developed for operations on the human brain. Narabayashi[15] has devised his own stereotactic instrument to inject procaine in oil into the globus pallidus. Fenelon[10] has devised a direct method for "sub-pallidal" or ansa lenticularis coagulation without use of a stereotactic instrument or roentgenographic control. Guiot[11] has also carried out direct coagulation of the mesial globus pallidus and ansa lenticularis principally by an opened subfrontal operation. Each of these investigators has reported the alleviation of tremor and rigidity without necessarily inflicting a pyramidal tract lesion or paralysis upon the patient. Detailed and documented long-term follow-up studies of these patients eventually will help to evaluate what assets or deficits each particular technic may have. It is not unlikely that various neurosurgeons will be able to approach the region of the basal ganglia with salutary results employing various technics. A further period of objective evaluation and perfection of technics is the only way in which this matter can be clarified.

During the past 3 years two original technics have been developed on our neurosurgical service and have thus far been employed in a personal series of 145 patients.[5, 6, 7, 8] I would like to briefly describe each of these technics and list our current results of some of our longer term follow-up patients.

SURGICAL OCCLUSION OF THE ANTERIOR CHOROIDAL ARTERY

The anterior choroidal artery has been demonstrated by Abbie to be the principal source of blood supply for the mesial part of the globus pallidus and its efferent connections through the ansa lenticularis with the corpus subthalamicum, ventrolateral nucleus of the thalamus, substantia nigra, and red nucleus. Abbie stated that these structures together with the anterior choroidal artery developed phylogenetically as a "functional unit". It has been our hypothesis that occlusion of the anterior choroidal artery might destroy the mesial globus pallidus, as well as certain other parts of this functional unit. Our surgical investigation has been based upon this hypothesis which was developed subsequent to one patient in whom the anterior choroidal artery was unintentionally sacrificed.

The surgical details of occlusion of the anterior choroidal artery have been described elsewhere and need not be repeated.

During the past 3 years, anterior choroidal artery occlusion has been performed on our own service 55 times. The mortality rate is 10 per cent. There were 3 cases of hemiplegia. Seventy per cent of the patients in the series demonstrated good results which have persisted up to the present time. This signifies virtual alleviation of tremor and rigidity of the extremities contralateral to the operation without any sacrifice of motor power. In addition, in several instances, there was noted marked improvement in masked facies, gait, speed of voluntary acts and reversal of previous fixed deformities. The operation of anterior choroidal artery should be limited to patients under the age of 55 with long-standing parkinsonian symptomatology and incapacitation.

CHEMOPALLIDECTOMY

In our search for a neurosurgical technic which could be used not only in young parkinsonian patients but also in geriatric parkinsonians, we have developed a procedure now referred to as chemopallidectomy.[8] This technic too has been described in detail elsewhere and will not be elaborated upon.

In brief, we have developed a relatively simple method for introduction of a small polyethylene catheter, either directly by hand or with the aid of a simple 6 ounce needle guide we have developed, into the region of the mesial globus pallidus. Procaine then is injected into this region. In this way, the particular site is located, procainization of which will abolish tremor and rigidity of the contralateral extremities. Once the correct site has thus been localized, more lasting results can be achieved by producing a destructive lesion in the same area. We have experimented with several different ways of producing this destructive lesion including electrolysis, radio-frequency current, projection of a small knife blade into the region and injection of absolute alcohol. The best results which we have obtained thus far have been with absolute alcohol. We currently are employing a solution containing 8 per cent celloidin in 95 per cent ethanol. This solution has the neurolytic properties of absolute alcohol but is viscous and very easily controllable during injection into the brain. Others currently are investigating the use of a small radioactive bead and ultrasonic vibrations to produce intracerebral destructive lesions. Each of these appear to have great potential merit and undoubtedly, many technical improvements in all technics will be forthcoming.

The operation of chemopallidectomy has been performed 90 times. The mortality rate up to this time is 3.3 per cent. The patients have been complicated by hemiparesis. Seventy per cent of the patients now show good results during the follow-up period of this study. That is, since the time of operation these patients have had alleviation of tremor and rigidity in the opposite extremities. The longest follow-up period for chemopallidectomy is now 18 months, whereas some patients have been followed for 3 years in the series of patients who have undergone anterior choroidal artery occlusion. The operation of chemopallidectomy now has been employed in many patients between the age of 60 and 65 years. The operation is tolerated well by selected patients in this older age group and is, as far as I can determine, the first neurosurgical approach which can be used with a reasonable degree of safety in patients in the seventh decade of life.

THE PRESENT STATUS OF NEUROSURGICAL THERAPY

It is my opinion, as stated previously, that neurosurgical therapy of parkinsonism has now reached the stage in which it can be considered as a practical, useful, reasonably safe, and rewarding method of therapy in many instances of carefully advanced cases of parkinsonism. However, this is not to say that surgery should be considered in every case of parkinsonism or that it will be successful in every patient who is selected for operation.

Certain important scientific steps must be taken in order for neurosurgical

technics in parkinsonism to serve the useful and essential role in the therapy of this disease of which it is potentially capable. These steps are:

1. A new physiologic, diagnostic evaluation of patients with this syndrome. Since parkinsonism is merely a complex of a group of symptoms, a more descriptive and physiologic nomenclature is needed in evaluating each case. Neurosurgical therapy is aimed at specific symptoms and signs of the complex. Therefore, before any patient can be considered as a candidate for neurosurgical therapy, the individual signs and symptoms in that particular case must be carefully assessed, in a more specific way than has heretofore been the rule.

2. An objective, scientific evaluation of the results obtained by various technics must be forthcoming. So much of the medical literature regarding the possibilities of various therapies for parkinsonism has been beclouded by statements which are not supported by fact, that it is particularly essential that this type of case be assessed in as scientific a manner as possible. To this end, I have arranged for the patients in my own investigation to be examined and appraised objectively by two groups who have not played a part in the development of these particular neurosurgical technics. Dr. Leonard Diller and his associates are compiling a separate statistical follow-up study on all the patients who have been operated upon during this investigation. In addition, Dr. Robert S. Schwab, Director of the Parkinsonism Clinic at Massachusetts General Hospital, has accepted my invitation to evaluate personally the follow-up results in this same series of patients. It is my hope that these studies will not only provide an objective evaluation of the results which have been obtained in my own series, but also will serve as a basis for the type of evaluation which is necessary for similar investigations in this field.

SUMMARY

It has been the intention of this presentation to describe the past efforts of neurosurgeons to alleviate the symptoms of parkinsonism and to summarize the status of current efforts. There still is much more unknown about parkinsonism and its therapy than is known at the present time. However, there are certain conclusions which now can be substantiated by fact. These conclusions are:

1. The most profitable approach to the neurosurgery of parkinsonism at the present time is surgery of the basal ganglia, particularly the globus pallidus. Two original technics which have been used in a series of 145 patients have been described and some of the results presented. As I have indicated, others in this country and abroad have been developing surgical technic aimed at the basal ganglia and have reported promising and hopeful results.

2. Tremor and rigidity of parkinsonism can be relieved neurosurgically without sacrificing motor power. In my own experience such relief has been demonstrated to persist for as long as 3 years without any recurrence of symptoms up to the present time. In some patients other stigmas of the disease have been alleviated as well. Not all cases are suitable subjects for surgical intervention. Of those patients operated upon in our series of cases 70 per cent have received lasting alleviation of tremor and rigidity.

3. In addition to the perfection of surgical technics, particular attention should be paid to the selection of patients as possible candidates for neurosurgical therapy and to the development of a more useful classification of patients with the parkinsonian symptom complex.

4. There is a factual basis for judicious optimism regarding the future contributions of neurosurgical therapy to the welfare of patients with parkinsonism. In order for these potentialities to be realized, patients must be cautiously and judiciously selected as candidates for operation and operations of documented merit must be painstakingly performed.

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OBSTRUCTION OF THE SMALL BOWEL DUE TO BOLI OF INGESTED COCONUT: A REPORT OF TWO CASES

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In 1854, Quain[4] reported for the first time in the medical literature a case of a phytobezoar. He recorded the case of a bezoar occurring in the stomach of an epileptic person whose death was caused by perforation of a gastric ulcer producing peritonitis. The bezoar was composed almost entirely of coconut fibers and bits of string. Since 1854, although many reports of phytobezoars have appeared, there has been no subsequent mention of coconut bezoars. No recorded cases could be found of intestinal obstruction due to a coconut bolus.

Two cases of intestinal obstruction caused by boli of coconut were seen at the Duval County Medical Center between 1948 and 1950. Because of their apparent rarity it was thought that these cases would be of interest.

CASE REPORTS

Case No. 1: A 49 year old obese woman was admitted to the Duval County Medical Center on July 21, 1948 complaining of cramping epigastic pain of 25 hours' duration. Just before the onset of the pain she had eaten an entire coconut pie. Shortly after the onset of pain the patient became nauseated and vomited several times. She had neither bowel movements nor passage of flatus for 2–3 days before her admission to the hospital.

On physical examination, tenderness was elicited over the epigastrium on direct pressure but no rebound tenderness or muscle spasm was found. It also was noted on examination that upper and lower dentures were present. The white blood cell count on admission was 15,000 per cu. mm. with 70 per cent polymorphonuclear neutrophils. There was no history of previous gastrointestinal disturbance. A tentative diagnosis of gastroenteritis was made and treatment with sulfadiazine was started. The patient's abdominal pain continued with intermittent vomiting and abdominal distention became apparent on the third hospital day. A Cantor tube was inserted and several enemas were given without producing relief of the distention. The white blood cell count remained about 15,000 per cu. mm. and the temperature was elevated each day to 100 degrees. Roentgenograms taken on the third and fourth hospital days showed distented loops of small bowel and a questionable fluid level.

Approximately 72 hours after admission, a laparotomy was done under spinal anesthesia. A mass, 5 by 3.5 cm., which could be identified as coconut meat fibers because the fibers could be seen through the distended intestine wall, was found at the junction of the middle and lower third of the jejunum. This was broken up by manual pressure through the bowel wall. It was not considered necessary to open the small bowel. The abdominal incision was closed.

The patient had a bowel movement on the first postoperative day and her distention disappeared rapidly. The Cantor tube was removed on the third postoperative day and she was discharged from the hospital on the seventh postoperative day. She has remained well during the 7 years since her hospital admission.

Case No. 2*: A 47 year old woman was first admitted to the Duval Medical Center in 1948. She had symptoms of peptic ulcer for 15 years before admission and a closure of a

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* This case is from the service of Dr. F. Gordon King.

perforated gastric ulcer had been done elsewhere 6 months before admission. Twenty-eight years earlier she had had a lower abdominal operation which she believed to have been a hysterectomy. There was a ventral hernia at the site of the lower abdominal incision. During this hospital stay a subtotal gastrectomy and gastrojejunostomy of the Hoffmeister type was performed. The operating surgeon estimated that 75 per cent of the stomach was removed. One month after discharge the patient was admitted to the Duval Medical Center for a lung abscess which cleared without operative treatment.

The patient re-entered the Duval County Medical Center on April 10, 1950 with a 2 day history of intermittent crampy, abdominal pain. The day before admission she had vomited and recognized, in the vomitus, food she had eaten 24 hours earlier. She had a normal bowel movement 2 days before admission but none since, although she had passed flatus. The patient had epigastric tenderness and moderate abdominal distention. On auscultation of the abdomen, peristaltic "*rushes*" could be heard. The rectum was empty and felt "*collapsed*". The urine showed 3 plus sugar, the white blood cell count was 6,300 per cu. mm. and the red blood cell count was 3,380,000 per cu. mm. with a hemoglobin of 11.5 grams. Another white blood cell count later the same day was 14,200 per cu. mm. with 78 per cent polymorphonuclear neutrophils. The temperature was 101 and the pulse was 68. A roentgenogram of the abdomen showed gas in the small bowel but no fluid levels. A diagnosis of mechanical intestinal obstruction was made and at laparotomy, a firm mass, 5 cm. in diameter was found obstructing the ileum 60 cm. proximal to the ileocecal junction. A longitudinal incision was made over the mass and a bolus of coconut and peas was removed. The bowel was closed transversely and the abdomen was closed. The patient had difficulty raising tracheobronchial secretions for the first 3 or 4 days after operation. She was discharged on the ninth postoperative day.

Bezoars are divided etiologically into two large groups: The trichobezoars or hair balls and the phytobezoars composed of vegetable fibers. DeBakey and Ochsner[1] in an analysis of 311 collected cases found 172 cases of trichobezoars, 126 cases of phytobezoars and 13 concretions. They subdivided the phytobezoars into 92 caused by persimmons and 34 caused by other vegetable fibers. In their series 91.4 per cent of the trichobezoars occurred in females, whereas, 77 per cent of the phytobezoars occurred in males. In 92 collected cases of diospyrobezoars (due to persimmon) 17.3 per cent were in the intestine and 4.4 per cent were in both the stomach and intestine.

Fantus and Kopstein[3] collected 52 cases of intestinal obstruction due to foods. In their series there were several factors considered as predisposing to obstruction by foods. Seven patients had undergone abdominal surgery at some time before the obstructive episode and 6 were known to be edentulous. The site of the obstruction was the jejunum in 3, the ileum in 38, the ileocecal junction in 1, the colon in 4, the rectum in 5, and in 1 patient not stated. The mortality rate was slightly over 30 per cent.

Elliott[2] presented an excellent review of the literature and a fatal case of intestinal obstruction due to eating oranges.

The 2 patients presented in the report were both women in their late forties. In Case # 1, the only physical factor which might be considered as contributing was the presence of upper and lower dentures. It should be noted that this woman ate an unusually large amount of coconut. The patient in Case # 2 had had three abdominal operations. At one of these a large part of the stomach was removed which possibly contributed to passage of poorly digested or undigested food into

the small intestine. Enterotomy was considered necessary in one patient but not in the other. The location of the bolus in Case # 1 was the jejunum and in Case # 2 the ileum. Both patients recovered from the obstruction and the operations.

SUMMARY

Two cases are presented of small bowel obstruction due to coconut.

ADDENDUM

Another case of intestinal obstruction due to ingestion of coconut in a patient who had a gastrectomy has come to our attention. Perhaps patients who have had a gastrectomy should avoid this food.

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CHOLECYSTOSTOMY IN MODERN SURGERY

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Since cholecystostomy was first performed by Dr. John S. Bobbs, less than 80 years ago, cholecystectomy (Lagenbruech, 1882) and cholecystography (Graham and Cole, 1923) have made diagnosis and treatment of gallbladder disease more definitive than mere drainage alone was able to do. As a result, surgical practice has justifiably utilized cholecystectomy in preference to cholecystostomy such that the rare practice of draining a gallbladder threatens its being lost from surgical training. To emphasize the important, albeit infrequent, need of this procedure and to survey the modern experience with it, the following study was conducted.

Material: Since individual experience with this procedure is scant, the accumulated cases of cholecystostomy performed during recent years in three teaching hospitals of St. Louis (Barnes, City, St. John's) were reviewed (table 1).* Illustrating the limited experience of any individual surgeon, these 72 cases were performed by 55 different surgeons and the average number performed annually varied from 2 to 4 per hospital. During this same period, 2,719 gallbladders were removed, a ratio of removal to drainage of about 40 to 1. (In 468 patients treated surgically for acute cholecystitis, Ochsner[7] performed cholecystectomy in 91 per cent of cases and cholecystostomy in 12 per cent.

Age and Sex: Three-fourths of these patients were older than 60 years of age (table 2) and most of them were critically ill, aged people. There were more men than women which is the reverse incidence of biliary tract disease in younger individuals. Others[3, 4] also have reported the altered sex ratio of biliary disease in aged population which probably results from the almost equal involvement of gallbladders by stones and arteriosclerosis in both men and women beyond the age of 50 years.

Mortality: The postoperative mortality rate in these 72 cases was 30 per cent (22 deaths). This high rate of mortality reflects the critically ill state of most of these patients at the time of operation. However, other factors also are involved. It appears in some cases that the operator's desire to explore further than the gallbladder may have interfered with the localizing processes of defense already established. In an extremely debilitated patient with evident acute cholecystitis, local drainage alone without more extensive abdominal exploration and severance of localizing adhesions may be safer. In other cases, unusually long periods of downhill course were observed during hospitalization before final decision to drain the gallbladder was reached. Therefore, once the nature of the disease is recognized and an unsatisfactory response is made to nonoperative management, an early decision to perform cholecystostomy or cholecystectomy should lessen the incidence of morbidity and mortality.

* Barnes 1947–1955, City 1947–1956, St. John's 1951–56.

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TABLE 1

Case No.	Age	Sex	Preoperative Condition	Time between Onset of Acute Symptoms and Operation	Anesthetic	Operative Findings	Outcome
1	73	M	Cardiac decompensation.	3 weeks prior to admission. 7 days to "prepare patient".	Intercostal block.	Gangrenous gallbladder.	Died 3 hours post-operative.
2	76	M	Critical.	1 day.	Intercostal and local.	Perforated gallbladder with stones and pericholecystic abscess.	Died 13th post-operative day. Pneumonia and decompensation.
3	73	M	Critical. Cardiac decompensation.	4 days prior to admission. 19 days in hospital.	Pentothal, N_2O, O_2.	Perforated empyema of gallbladder with stones and abscess.	Died 5th post-operative day on bedpan, after excellent post-operative course.
4	41	F	Serious. Four month's pregnancy.	1 day prior to admission. 2 days in hospital.	Pentothal, Cyclo., N_2O, O_2.	Acute cholecystitis with much acute inflammatory fixation.	Recovered.
5	63	F	Critical. Active tuberculosis.	3 weeks prior to admission. 2 days in hospital.	Intercostal.	Acute cholecystitis with stones and with cancer and liver metastases.	Survived 2 months.
6	81	F	Critical. Jaundiced.	6 weeks prior to admission. 6 days in hospital with progressive worsening and diagnosis of "infectious hepatitis".	Pentothal, G.O.E., endotracheal.	Acute cholecystitis with stones.	Died 1st post-operative day.
7	69	F	Critical. Jaundice. Diabetes. 5 days after admission developed acute pancreatitis (diastase 800).	3 days prior to admission. 9 days in hospital.	Local.	Acute cholecystitis with stones.	Died 4th post-operative day.
8	74	M	Fair.	2 days prior to admission. Operated day of admission.	Spinal.	Gangrenous gallbladder, surrounded by stomach and omentum. General purulent peritonitis.	Discharged 21st post-operative day. Returned 5 years later and acute gallbladder was removed with recovery.
9	66	F	Good. Localized peritonitis R.U.Q.	6 days prior to admission. 2 days in hospi-	Pentothal, curare, Endotracheal	Acute cholecystitis with stones. Pericholecystic	Recovered. Cholecystectomy and exploration

9	66	F	Good. Localized peritonitis R.U.Q. Acute pancreatitis (Diastase 1188). Obstructive jaundice.	6 days prior to admission. 2 days in hospital.	Pentothal, curare, Endotracheal G.O.E.	Acute cholecystitis with stones. Pericholecystic abscess, localized.	Recovered. Cholecystectomy and exploration c. d. 6 weeks later.
10	70	M	Critical. Abdominoperineal resection two months previously.	2–3 weeks (?) prior to operation.	Intercostal.	Acute cholecystitis without stones.	Died 17th post-operative day.
11	77	M	Critical. Pseudomonas septicemia on admission.	2 days prior to admission. 5 days in hospital.	Pentothal. G.O.E.	Empyema of gallbladder.	Died 9th post-operative day.
12	77	M	Critical. Diabetic.	2 weeks prior to admission. Operated day of admission.	Pentothal, intercostal block, endotracheal N_2O, O_2.	Empyema of gallbladder with stones.	Recovered.
13	64	M	Critical.	20 hours prior to admission. Operated same day of admission.	Intercostal.	Acute cholecystitis. No stones seen.	Discharged 15th post-operative day. Returned for elective removal of gallbladder with stones 2 weeks later.
14	25	F	Serious.	5 days prior to admission at onset of abortion. 12 days in hospital.	G.O.E.	Acute cholecystitis with stones and pericholecystic abscess.	Recovered.
15	77	F	Critical. Obese. Progressively worse in hospital.	6 days prior to admission. 3 days in hospital.	Intercostal and local. (Not effective). Pentothal, curare, N_2O, O_2.	Empyema of gallbladder with stones.	Recovered. Elective removal of gallbladder and exploration of common duct 6 weeks later.
16	43	F	Serious. Pelvic evisceration 6 months previously.	3 days prior to admission. Operation on day admitted.	Pentothal and cyclopropane.	Acute cholecystitis with stones.	Recovered.
17	88	M	Critical. Invalid 29 years. Myriad degenerative diseases. Cataract operation 2 weeks before.		Local. Pentothal, curare, cyclopropane.	Perforated, gangrenous gallbladder with bile peritonitis.	Died 8th post-operative day, of pneumonia and bile peritonitis.

TABLE 1—*Cont.*

Case No.	Age	Sex	Preoperative Condition	Time between Onset of Acute Symptoms and Operation	Anesthetic	Operative Findings	Outcome
18	81	M	Critical.	2 days prior to admission. Operated 1st hospital day.	Continuous spinal. G.O.E.	Acute cholecystitis with stones, perforated with generalized peritonitis.	Died 3 weeks post-operative of uremia and urinary failure.
19	63	M	Critical.	2 days prior to admission. 1 day in hospital.	Unknown.	Gangrene of gallbladder without stones.	Recovered.
20	86	M	Critical.	2 days prior to admission, 4 weeks in hospital.	Intercostal and local.	Gangrene of gallbladder with stones.	Died 21st post-operative day with cancer of stomach, malnutrition, and pericholecystic abscess.
21	64	M	Serious.	1 day prior to admission. 1 day in hospital.	Spinal.	Empyema of gallbladder.	Recovered.
22	76	M	Serious.	2 months prior to admission. 4 days in hospital.	Intercostal.	Cancer and hydrops of gallbladder with stones.	Recovered.
23	49	F	Serious. Hysterectomy 2½ months previously following which gallbladder attacks began.	3 days prior to admission. 1 day in hospital.	Pentothal. G.O.E.	Hydrops and acute cholecystitis with stone in cystic duct.	Recovered.
24	35	F	Serious. Obstructing duodenal ulcer.	1 week prior to admission. 3 weeks in hospital.	G.O.E., intercostal, pentothal.	Normal gallbladder. Enlarged head of pancreas. Chronic duodenal ulcer. Gastroenterostomy also done.	Recovered. Two weeks later, gastrectomy was done.
25	73	F	Serious. Also had rec. cancer uterus.	4 days prior to admission. 4 days in hospital.	G.O.E.	Acute cholecystitis with stones.	Recovered. Died 2 months later following operation for pelvic evisceration.

26	77	F	Critical.	4 days prior to admission. 2 days in hospital.	N_2O, intercostal, pentothal.	Empyema of gallbladder with stones.	Recovered.
27	58	F	Serious.	Months.	G.O.E.	Cancer head of pancreas. Whipple operation done and cholecystostomy was done as adjunct "safety factor".	Recovered.
28	55	F	Serious.	Jaundice. 4 months prior to admission.	G.O.E., pentothal.	Cancer of gallbladder with stones and liver metastases.	Recovered.
29	52	F	Good.	5 weeks (duodenal ulcer).	N_2O, pentothal, intercostal.	Chronic duodenal ulcer for which gastrectomy was performed. Gallbladder with stone also found and drained since ducts were involved in ulcer inflammation.	Recovered.
30	67	M	Serious. 3 days previously, had open reduction of fractured hip.	1 day.	Pentothal, G.O.E.	Gangrene of gallbladder without stone.	Recovered.
31	87	M	Very poor risk. Jaundice.	2 months.	Intercostal, G.O.E.	Stones in common duct. (Removed).	Recovered.
32	43	F	Serious. Progressively worse in hospital. Hysterectomy 4 months previously.	1 day prior to admission. 5 days in hospital.	G.O.E., curare.	Empyema of gallbladder with stones.	Recovered.
33	77	F	Serious. Progressively worse in hospital.	1 day prior to admission. 6 days in hospital.	Pentothal, curare, G.O.E.	Acute cholecystitis with stones.	Recovered.

TABLE 1—*Cont.*

Case No.	Age	Sex	Preoperative Condition	Time between Onset of Acute Symptoms and Operation	Anesthetic	Operative Findings	Outcome
34	68	F	Serious. Progressively worse in hospital.	1 day prior to admission. 6 days in hospital.	Ether, curare.	Perforated gallbladder with stones and subphrenic abscess.	Recovered.
35	72	M	Good. Admitted for colectomy for cancer cecum. No symptoms referable to gallbladder.		G.O.E.	Cancer cecum. Incidental hydrops of gallbladder with stones.	Recovered.
36	77	M	Serious.	7 days prior to admission. 1 day in hospital.	G.O.E., intercostal.	Empyema of gallbladder with stones.	Recovered.
37	16	M	Serious. Operated 16 days before for debridement gunshot wounds of chest and abdomen.	1 day prior to admission. 1 day in hospital.	G.O.E.	Acute gallbladder with pericholecystic abscess and without stones.	Recovered.
38	42	M	Serious. Obstructive jaundice.	2 months prior to admission.	Pentothal, G.O.E., intercostal block.	Bile duct cancer obstructing common duct.	Died 2 weeks post-operative.
39	72	F	Serious. Increasing obstructive jaundice.	Months.	G.O.E., local.	Cancer head of pancreas.	Died 14th post-operative day.
40	69	F	Serious.	2 months prior to admission. 16 days in hospital.	G.O.E., pentothal, curare.	Posterior gastric perforating ulcer. Gastric resection done and gallbladder drained as "safety factor" in duodenal stump closure.	Recovered.
41	66	M	Serious. Right colectomy for cancer 2 weeks previously operated for post-operative adhesions 1 week previously.	1 week in hospital.	Spinal.	Gangrenous gallbladder without stones.	Recovered.
42	68	F	Serious. Progres-	3 days prior to admis-	G.O.E., endo-	Acute cholecystitis with	Recovered.

			ously.				
42	68	F	Serious. Progressively worse in hospital.	3 days prior to admission. 4 weeks in hospital.	G.O.E., endotracheal.	Acute cholecystitis with stones.	Recovered.
43	57	F	Serious. Diabetic.	10 days prior to admission. 3 weeks in hospital.	G.O.E., curare.	Acute gallbladder with stone and pericholecystic abscess.	Recovered.
44	68	F	Good. Admitted for elective removal of gallbladder.	Many years of episodes, none presently.	G.O.E., Pentothal.	Tiny, thick gallbladder with stones and small pericholecystic abscesses, apparently old.	Recovered.
45	36	F	Good. Not improving from acute cholecystitis.	1 day in hospital.	N_2O, O_2, Pentothal, local.	Empyema of gallbladder with stones.	Recovered. Elective removal of gallbladder 2 months later.
46	66	F	Good.	5 weeks of jaundice.	G.O.E., curare.	Papilloma at ampulla of vater (resected). Gallbladder drained for decompression effect.	Recovered.
47	53	F	Good.	2 months prior to admission. 6 days in hospital.	G.O.E.	Metastasis in liver from cancer of cervix (treated 3 years previously). Subacute cholecystitis with stones.	Recovered.
48	63	F	Poor.	3 months prior to admission.	G.O.E., pentothal.	Abdominal carcinomatosis from cancer of rectum. Removed 3 years previously. Stones in gallbladder incidentally found.	Died 30th post-operative day.
49	90	F	Critical.	1 week prior to admission. 1 week in hospital.	Local.	Empyema of gallbladder.	Died 7th post-operative day of uremia.
50	76	F	Serious.	7 weeks prior to admission. 12 days in hospital.	G.O.E., local.	Carcinomatosis of biliary ducts. Empyema and stones of gallbladder.	Died 7th post-operative day.
51	68	F	Critical.	2 hours prior to admission. 1 day in hospital.	G.O.E., curare.	Ruptured gallbladder with stones.	Died 21st post-operative day of multiple infirmities.

TABLE 1—*Cont.*

Case No.	Age	Sex	Preoperative Condition	Time between Onset of Acute Symptoms and Operation	Anesthetic	Operative Findings	Outcome
52	66	M	Serious. Did not improve in hospital.	1 day prior to admission. 5 days in hospital.	Spinal.	Acute cholecystitis with stones.	Recovered.
53	55	M	Good. Acute cholecystitis subsided in hospital.	1 day prior to admission. 13 days in hospital.	Spinal.	Acute cholecystitis without stones.	Recovered.
54	56	M	Good. Patient had operation for right femoral hernia 2 days before onset of right, upper quadrant symptoms.	2 days in hospital.	Spinal.	Acute cholecystitis without stones.	Recovered.
55	53	M	Good.	3 months prior to admission. 2 weeks in hospital.	Spinal.	Cancer head of pancreas. Gallbladder drained for decompression.	Recovered.
56	64	M	Critical.	5 months prior to admission. 6 days in hospital.	Spinal, pentothal.	Cancer pancreas and liver. Gangrene of gallbladder without stones.	Died 11th post-operative day.
57	78	F	Serious.	3 days prior to admission. 9 days in hospital.	Spinal.	Acute gallbladder with stones.	Recovered.
58	50	M	Serious. Operation for drainage of cervical abscess 3 weeks previously.	3 days prior to admission. 15 days in hospital.	Spinal.	Acute pancreatitis. Distended gallbladder without stone.	Recovered.
59	76	M	Serious.	1 day prior to admission. 28 days in hospital.	Spinal.	Cholecysto-duodenal fistula. Stone in gallbladder and in stomach. Latter removed by gastrotomy.	Died 5th post-operative day.
60	57	F	Good.	3 weeks prior to admission. 5 days in hospital.	Spinal.	Stones in gallbladder and common duct. Removed from both sites.	Recovered.

				1 day prior to admis-	Pentothal and spi-	Acute cholecystitis with	Recovered.

				tal.			moved from both sites.
61	68	M	Serious. Evidences of mild, localized cholecystitis.	1 day prior to admission. 1 day in hospital.	Pentothal and spinal.	Acute cholecystitis with stones.	Recovered.
62	70	F	Serious. Recovering from fracture of pelvis 2 months previously.	3 days prior to admission. 1 day in hospital.	Local.	Gangrene of gallbladder, without stones, pericholecystic abscess.	Recovered. Recurrence of symptoms 2½ years later with cholecystectomy. No stones.
63	83	F	Critical. G.I. hemorrhage, jaundice.	1 month prior to adsion. 17 days in hospital.	Pentothal, spinal.	Cancer head of pancreas.	Died one month.
64	67	M	Serious.	3 days prior to admission. 4 days in hospital.	Pentothal, spinal.	Acute gallbladder without stones.	Recovered.
65	86	F	Critical. Jaundiced.	3 months prior to admission. 5 weeks in hospital.	Local, N_2O, triline.	Cancer of gallbladder with common duct stones.	Died 1st post-operative day.
66	20	M	Excellent.	3 weeks prior to admission. 1 day in hospital.	Spinal.	Acute cholecystitis with stones, subsiding.	Recovered. Elective removal of gallbladder 3 months later.
67	68	M	Good.	3 months prior to admission.	Pentothal, G.O.E.	Acute pancreatitis. No stones in gallbladder.	Recovered.
68	78	M	Excellent.	1 day prior to admission. 7 days in hospital.	Pentothal, spinal.	Acute cholecystitis with stones.	Recovered.
69	73	M	Serious.	2 days prior to admission.	Pentothal, spinal.	Acute cholecystitis with stone.	Recovered.
70	69	M	Serious. Fever, mass, jaundice worsening. Resection of colon 6 months previously.	8 days prior to admission. 10 days in hospital.	Pentothal, spinal.	Ruptured gallbladder with stones and hemorrhage.	Died 4th post-operative day.
71	40	M	Good.	3 days prior to admission.	Pentothal, spinal, subcostal block.	Subacute cholecystitis with stones.	Recovered.
72	85	M	Critical.	3 days prior to admission. Operated 1st hospital day.	Spinal.	Acute calculous cholecystitis with general peritonitis.	Recovered. Returned with recurrent attack 4 months later and had gallbladder removed.

TABLE 2

Age and sex in 72 cases of cholecystostomy

Age in Years	Male	Female
90–100	0	1
80–90	6	3
70–80	12	8
60–70	11	10
50–60	5	5
40–50	2	4
30–40	0	2
20–30	0	2
10–20	1	0
Total	37	35

INDICATIONS FOR OPERATION

I. *Acute Cholecystitis:* In this series of cholecystostomies, the commonest indication for the operation was acute cholecystitis and its complications. While the operation of choice for acute cholecystitis is removal of the gallbladder, the application of drainage only was made when failure of relief by nonoperative management was evident and: (1) The general state of debility was so great as to interdict the added risk of cholecystectomy, or (2) The technical difficulties of cholecystectomy in the presence of brawny inflammatory reaction were considered too hazardous.

The proper selection of operative appointment is as important as the decision to operate, and in some cases morbidity and mortality might have been favorably influenced by operating earlier. While evidence continues to accumulate in behalf of early cholecystectomy as the treatment par excellance for acute cholecystitis (within the first 3 days of acute illness), it also appears increasingly evident that after this initial period of vascular alterations, operation should not be undertaken unless the clinical course is one of worsening. Under the latter circumstance, the decision to operate should be made promptly. Little justification can exist for delaying operation for more than 24–28 hours if the progression of acute cholecystitis is not controlled by medical management. Differential diagnosis may cause delay occasionally, although in this series it did not, and delays of 6–12 days of critical status prior to operation were almost always followed by unfavorable outcome, forcefully suggesting a need for greater expedience in resorting to surgical intervention in such patients.

Acute inflammation of the gallbladder necessitated cholecystostomy in 56 cases in which there occurred 17 deaths. Seven cases were complicated by free perforation and generalized bile peritonitis, and of these seven, 6 patients died. This experience coincides with the ominous results generally encountered with free perforation of the gallbladder and biliary peritonitis. Of the 12 patients (20 per cent) who had acute noncalculous cholecystitis (table 5), all except one were past the age of 50 years and 8 (⅔) had experienced recent operation or injury.

TABLE 3

Cholecystostomy performed for acute cholecystitis

	Cases	Deaths
Without free perforation	49	11
With free perforation	7	6
Total	56	17

II. *Biliary Disease Other than Acute Cholecystitis:* In 11 cases, cholecystostomy was performed as a primary attack on *disease of the biliary tract* other than acute cholecystitis.

When performed as a primary decompression procedure in carcinoma of the gallbladder, pancreas, or bile duct (7 cases), the debility of the patients and the advancement of the malignant disease were both so extensive as to warrant only the simplest maneuver which might decompress the obstructed biliary system as a palliative procedure. Six of these patients died and on the basis of this experience, one questions whether adding an external biliary fistula should be considered palliation in its true sense. Cholecystojejunostomy has earned a position of preference in decompressing such extrahepatic, malignant lesions since it avoids the complications of external biliary drainage.

Decompression of the biliary tract in instances of acute pancreatitis has had its theoretical supporters since the initial report of Opie's now famous case of calculus in the ampulla of Vater. It is, however, the general concensus that operation for acute pancreatitis should be avoided except in that occasional case requiring drainage of an abscess. Decompression of the gallbladder when acute pancreatitis is found by surprise at exploration of the abdomen is a procedure of questionable merit, although the 3 patients so operated upon in this series survived.

III. *Extrabiliary Tract Lesions:* As an ancillary procedure to other operations, cholecystostomy was performed on 5 patients (table 4) with satisfactory results. In each instance, the surgeon thought that the primary disease (or operation) so encroached by edema or other inflammatory reaction upon the common duct, that danger of biliary obstruction and colangitis existed.

Noncalculous Cholecystitis: That all acute cholecystitis does not emanate from gallbladder calculi has become certain. The cause of acute cholecystitis is undetermined but there is increasing evidence to the effect that the aging processes in the cystic vessels and in biliary secretion may be etiologic factors in some cases (table 5). Furthermore, the relationship between previous operations and acute cholecystitis is of such frequency as to be more than coincidental (table 6). In this series, 12 patients developed acute cholecystitis within relatively short periods of days to months following other operations. Four of these patients had stones, while the remaining 8 (comprising $\frac{2}{3}$ of the group) had acute noncalculous cholecystitis (table 6). This subject is well presented and reviewed by Glenn & Wantz[3] who hypothecate that a prolonged period of fasting, postoperative immobilization, bile restricting drugs, acute systemic disease and infection, and the resumption

TABLE 4

Cholecystostomy performed for decompression

	Cases	Deaths
As primary procedure		
Cancer of gallbladder	1	1
Cancer of pancreas	4	3
Cancer of common duct	2	2
Stone of common duct	1	0
Acute pancreatitis	3	0
As ancillary procedure		
Excision papilloma at ampulla of Vater	1	0
Operation for obstructing duodenal ulcer	3	0
Whipple operation for cancer of pancreas	1	0
Total	16	6

TABLE 5

Acute non-calculous cholecystitis

Age in Years	Cases
10–20	1
50–60	2
60–70	5
70–80	2
80–90	1
90–100	1
Total	12

of large feedings—particularly high in fat—postoperatively may all be factors which contribute to the development of acute postoperative cholecystitis and that, therefore, these factors should be combatted in the postoperative courses of all patients, particularly aged ones. That secretory dysfunction and stasis following periods of starvation may be factors of considerable significance is further suggested by one of the cases of acute pancreatitis in this series (#58) which followed an operation for drainage of a cervical abscess and by a case presented by McDermott[5] of an athletic 18 year old boy who developed acute pancreatitis following the sudden ingestion of a huge amount of food after a period of prolonged starvation and dehydration.

Technic of Operation: There is no need to duplicate the description of this procedure which is amply described and illustrated in numerous surgical texts. However, from the experience in these cases, it appears wise to recommend that in a debilitated, critically ill patient with a gallbladder mass for whom the decision has been made to perform cholecystostomy, the slightest amount of manipulative surgery which can be done is best. A small incision made over the

TABLE 6

Acute cholecystitis following operations or trauma

Operation	Time before gallbladder drainage	Outcome	Number of Cases
	With Stones (4)		
Pelvic eviseration	6 months	Recovered	1
Hysterectomy	2½ months	Recovered	2
Resection of colon	6 months	Died	1
Total			4
	Without Stones (8)		
Abdomino-perineal resection	2 months	Died	1
Cataract extraction	2 weeks	Died	1
Open reduction Fractured hip	3 days	Recovered	1
Debridement gunshot wounds	16 days	Recovered	1
Right colectomy	1 week	Recovered	2
Herniorrhaphy	2 days	Recovered	1
Fracture of pelvis	2 months	Recovered	1
Total			8

mass, taking precautions not to disturb the natural pericholecystic adhesions should be made, and the urge to satisfy academic curiosity by performing further exploration should be restrained.

Fate of the Gallbladder Treated by Cholecystostomy. In cases in which cholecystostomy has been performed as a palliative procedure or as a temporary decompression procedure in association with lesions outside of the biliary tract, the fate of the gallbladder is easily predictable. However, one should wisely question what becomes of the gallbladder following drainage for acute cholecystitis with or without stones. Many patients in this series are lost to follow-up, although it is known that of the 39 patients who survived cholecystostomy for acute cholecystitis, 8 (20 per cent) subsequently underwent operation for removal of the organ. Five of these patients had elective removal performed (table 7) and 3 of them (all past the age of 70) returned for removal of the gallbladder as an emergency procedure in attacks of recurrent acute cholecystitis. Gray and associates[4] reported on 97 survivors of a group of 103 cases of cholecystostomy for acute cholecystitis in a 5 year follow-up study and found that ⅓ of the patients required subsequent operations on the gallbladder. They concluded that cholecystostomy will result in relief of symptoms referable to the gallbladder for at least 5 years in most cases. Clark and Livingston[2] reported their follow-up study on 221 cases of cholecystostomy in which 60 per cent of the patients remained symptom free. They concluded that removal of the gallbladder following cholecystostomy for acute cholecystitis would seem to be indicated only in those patients subsequently developing gallbladder disease.

TABLE 7

Fate of survivors (39) of cholecystostomy for acute cholecystitis

I. Elective cholecystectomy	5
Time: 4–12 weeks following drainage	
Sex: 3 females, 2 males	
Age: 20 to 77 years	
II. Emergency cholecystectomy at subsequent attact	3
Time: 4 months, 2½ years, 5 years	
Sex: 1 female, 2 males	
Age: 74, 70, 85	
III. Not returned to hospital	31
Total	39
Mortality in cholecystectomy—None	

Glenn and Wantz[3] on the basis of their experience with a group of 103 patients with nonmalignant disease of the biliary tract upon whom cholecystostomy had been performed, recommend removal of the gallbladder within the following 6 months when it may be undertaken under optimum circumstances. In patients whose life expectancy is less than 2 years, they believe elective cholecystectomy to be unnecessary.

This experience with patients who underwent cholecystostomy for acute cholecystitis is similar to that of other observers and prompts agreement with the recommendation that elective cholecystectomy be performed for those patients who have reasonable life expectancy and who do not have serious medical contraindications to an operative procedure.

CONCLUSION

Seventy-two cases of cholecystostomy performed by 55 surgeons are presented. The material is analyzed and conclusions are presented regarding the age and sex distribution and the indications for which the operations were performed. The incidence and results in noncalculous cholecystitis are presented as also are the cases of acute cholecystitis following surgical operations or trauma. Finally, the fate of the gallbladder following cholecystostomy is discussed.

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DISCUSSION

Dr. Costello's discussion calls attention to a procedure almost forgotten in present day surgery. Cholecystostomy as a definitive procedure in acute cholecystitis, with or without calculus disease, has almost lost its identity.

A review of the gallbladder surgery performed by the three senior surgeons of the Snyder Clinic at the two hospitals in Winfield, Kansas during the past 8 years emphasizes the above statements. Four hundred and sixty-eight patients were subjected to gallbladder surgery. Four patients had cholecystostomy. Three survived and one ended in a fatality. The other patients were subjected to cholecystectomy plus other definitive procedures as choledocholithotomy and choledochostomy, gastrectomy and appendectomy.

The 4 cholecystostomy patients were women, varying in age from 65 to 87 years of age. The cholecystectomy group ranged from 22 years of age to 90 years of age. There was 1 mortality in the 4 cholecystostomy cases. There were 10 mortalities in the 464 cholecystectomies. Seventy-four per cent of the cases were women. The average age of the entire group was 52.

The fatality in the cholecystostomy group was a woman, aged 65, who had had a previous cholecystostomy years before. On admission it was found at surgery that she had an acute hemorrhagic pancreatitis with generalized peritonitis. Her gallbladder was small and contracted and not inflamed and contained no stones. The gallbladder was drained and concentrated, thick, green bile obtained. At death, two months following surgery, autopsy revealed complete destruction of the entire pancreas with a fatty degeneration of the liver and also myocarditis. Cholecystostomy probably did not influence the end result.

The oldest of the cholecystostomy group, aged 87, was operated within 24 hours after onset of her nausea and vomiting, and severe upper abdominal pain. She had been on digitalis for a number of years. Her heart was compensated at the time of surgery. She was hydrated and put in electrolyte balance before surgery. A satisfactory regional nerve block and a local infiltration were used for anesthesia. The procedure consisting of opening the free end of the gallbladder with removal of stones, irrigation of the gallbladder and insertion of a tube for drainage. No adhesions were separated. Her recovery was uneventful and she left the hospital at the end of 18 days with the wound healed. She returned to the hospital, however, in 3 weeks with another episode of acute cholecystitis and on this admission was treated conservatively and recovered. A year later she fell and broke her hip and it was satisfactorily pinned with a good result. The next 2 years she had recurring symptoms and recurring jaundice related to her biliary system, and died 3 years following her original operation of emaciation and jaundice, at the age of 90. This woman probably had stones in the common duct and would have been better off with a cholecystectomy and exploration of the common duct and removal of common duct stones.

The third case, a woman aged 75, was admitted to the hospital in coma and jaundice, extremely ill, markedly dehydrated and anemic and showing a marked hypoproteinemia. Ten days were required to put this patient in electrolyte balance, to correct her anemia and hypoproteinemia. She then was subjected to surgery and cholecystostomy was performed and a subhepatic abscess drained.

Common bile duct was not explored. Following this she had a persistent biliary fistula and a month later was reopened and a stone was removed from the common duct. There had been no reformation of stones in the gallbladder. The gallbladder was not removed at the second procedure. The patient made an uneventful recovery and remained in good health until she was killed in a cyclone some 6 months later.

The fourth case, a woman aged 69, had carcinoma of the ampulla of Vater. She was so deeply jaundiced and in such poor electrolyte balance that she could not withstand a major procedure. Cholecystostomy was done preliminary to the performance of resection of the growth having its origin in the pancreatic portion of the common duct. After her jaundice cleared this patient had a subtotal gastrectomy, complete duodenectomy, partial jejunectomy, choledochojejunostomy, pancreatico-jejunostomy and gastrojejunostomy. Her recovery from the surgery was uneventful and she lived for 9 months before dying of metastases to her liver. Definitive surgery at the time of her first operation was not feasible. Cholecystostomy as a preparatory preparation was well justified.

Our ratio of cholecystostomies to cholecystectomies would be 1 in 115 cases. In reviewing the cholecystectomy group there was definitely one patient who should have had cholecystostomy. This patient was in poor condition, jaundiced, extremely ill, obese and had a mild diabetes at the time of his surgery. He was subjected to cholecystectomy and removal of stones from the common duct. He dehisced his wound 5 days following surgery and died a few days later of intestinal obstruction and pneumonia. A palliative procedure as cholecystostomy at the start followed by definitive surgery later would probably have changed the end result in this case.

The oldest of the cholecystectomy group, 90 years of age, had acute cholecystitis with calculus disease involving gallbladder and also had a stone in the common duct. After 3 days preparation in the hospital during which time she was digitalized for a decompensated heart, she was put in electrolyte balance and her hypoproteinemia was corrected. Cholecystectomy then was carried out along with removal of stone of the common duct. The patient left the hospital in 2 weeks with her T tube out; her wound healed; her convalescence following this was uneventful.

We insist on preoperative hydration of the patient, balancing of their electrolytes, correction of anemia and hypoproteinemia before surgery. If the patient then warrants it, it is our belief that definitive surgery should be carried out. Each case should be individualized and personalized. Individualized from the standpoint of the patient and personalized from the standpoint of the ability of the surgeon to do a definitive procedure.

I appreciate the opportunity to discuss Dr. Costello's paper.

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THE DIAGNOSTIC PERITONEAL TAP

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A very thin film of fluid normally covers the peritoneal surfaces within the abdomen. With each of the common acute surgical diseases of the abdomen, the quantity of this fluid increases and its characteristics are altered. The altered fluid characteristics have been studied by Steinberg[12] and Collier[2] but more from the standpoint of peritoneal response to various types of insult than specifically as an aid to diagnosis.

For many years, surgeons have noted the gross appearance and odor of the peritoneal fluid encountered upon opening the abdomen for some acute surgical disease. A "*prune juice*" appearance suggests acute pancreatitis; "*bloody*" fluid with a "*fetid*" odor suggests gangrenous bowel, or the appearance of "*whole blood*" suggests a ruptured solid viscus; "*milky*" odorless fluid suggests appendicitis; "*purulent*" fluid suggests peritonitis, frequently the result of a ruptured appendix; and greenish fluid containing particles of ingested food suggests a perforated ulcer. Most surgeons have associated certain types of fluid encountered at laparotomy with certain diagnoses and have utilized these associations in subsequent exploration by feeling first in the upper abdomen in those whose fluid suggests a perforated ulcer, or by feeling first in the lower abdomen in those whose fluid unexpectedly suggests a ruptured appendix. At this time, however, the abdominal incision has already been made. A knowledge of the peritoneal fluid, preoperatively, is sometimes helpful in locating the abdominal incision. It is of far greater help, however, in our decision as to whether or not operation is indicated. Often, when the diagnosis and the need for laparotomy is uncertain, to know that there is pus within the abdomen would greatly simplify the decision for laparotomy. This knowledge occasionally leads us to operate when, otherwise, our decision would be to observe.

Knowing fluid to be present and knowing the characteristics of this fluid is desirable in many instances wherein the need for operation is in doubt or wherein the diagnosis is questionable even though the need for operation is clear. Such information usually can be obtained by the diagnostic peritoneal tap.

Diagnostic paracentesis is not a new procedure. Its value in diagnosing primary peritonitis[4], strangulation of bowel[5], acute pancreatitis[7], and intra-abdominal hemorrhage[13] has been well illustrated.

Since the type of fluid present in the abdominal cavity can be of such diag-

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nostic help, why has there not been a more general acceptance of this procedure? The main deterrent to its common usage is fear of inserting a needle into the peritoneal cavity. It is hoped that this report will allay this fear and encourage a more general acceptance and utilization of this aid to diagnosis.

Safety of Procedure: There is an understandable but unwarranted fear of inserting a needle into the peritoneal cavity, based upon the impression that such a needle is likely to penetrate the bowel and cause leakage of its contents into the peritoneal cavity.

In our experience of 161 peritoneal taps, the needle has been known to enter the bowel on 8 occasions. The bowel may have been entered on other occasions but, if so, no bowel contents were aspirated to indicate such. Although it is true that the point of the needle usually touches the intestine, it rarely penetrates the bowel unless the loop is so fixed that it cannot slip out of the way. More important from the standpoint of possible danger to the patient than the rarity of the needle entering the bowel is the fact that, even if it does, no apparent harm results. In the 8 instances cited above in which the needle was known to have entered the intestine, the puncture wounds were not seen at operation and there was no evidence of leakage.

On many occasions during surgery we have, under direct vision, purposely run needles into different parts of the gastrointestinal tract and have seen no leakage of intestinal contents from the puncture wounds using needles as large as no. 15 gauge. Only once, when a no. 13 needle was used to puncture a greatly dilated loop of obstructed small bowel, did a few drops of intestinal contents ooze from the puncture site.

Neuhof and Cohen[10] observed no instance of injury to the intestine in an experience with more than 100 taps. Lien and Maddock[8], in an experimental study in dogs, saw no instance of peritonitis in a total of 300 punctures of the dogs intestine using a no. 14 gauge needle tangentially. Thompson and Brown[13] reported no complications in 300 diagnostic abdominal paracenteses.

Corpe[3] stated that in a series of 378,428 pneumoperitonei given as treatment for pulmonary tuberculosis at the Battey State Hospital in Rome, Georgia, no instance of peritonitis or of hemorrhage occurring as the result of the needle puncture has been encountered. In his series, the lumen of the bowel was entered on 12 occasions.

Moretz and Erickson[9] demonstrated that fresh needle punctures of the large and small bowel withstood, without leakage, intraluminal pressures many times that of any conceivable, normally occurring, intraluminal pressure.

To further demonstrate the safety of inserting a needle into the abdomen, the following experiments were carried out.

EXPERIMENTAL OBSERVATIONS

Experiment I (2 dogs). Using no. 18, 19, and 20 gauge needles and aseptic technic, 500 needle punctures were made in the anterior abdominal wall after the dog was anesthetized, producing the "*pin cushion*" effect seen in figure 1. No antibiotics were given. Except for a mild temperature elevation on the third

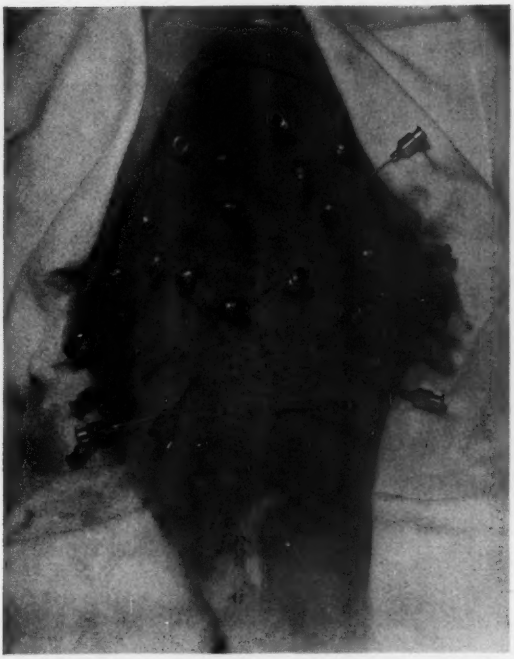

FIG. 1. The *"pin cushion"* effect of making 500 needle punctures of the anterior abdominal wall.

postoperative day in one dog, no ill effects were noted. When killed on the eleventh postoperative day, there was no visible evidence of harm within the abdomen from the punctures (fig. 2A) in one dog. In the other, killed on the seventh day, some loose fibrinous adhesions were present but there was no free fluid (fig. 2B).

Experiment II (2 dogs). Two hundred and fifty transabdominal wall punctures were made with similar needles, followed by immediate laparotomy. In each dog, small punctate wounds of the small and large bowel were visible (13 in one and 26 in the other) as well as multiple splenic punctures. Using No. 18 and 20 gauge needles, a total of 250 punctures were made in the stomach, small and large bowel. No visible spillage occurred from any site of puncture. A 1 inch segment of ileum was opened in one dog to see if the mucosa revealed evidence of injury after known penetration by needle. The injured area could not be identified internally with certainty. This 1 inch segment was removed and an end to end anastomosis accomplished. The abdominal wound was closed and the dogs were returned to their cages, without antibiotics, to have daily temperature recordings. One dog had a slight elevation of temperature (1.5°F.) on the first postoperative day.

Three weeks later, each was killed (fig. 3) and essentially normal appearing

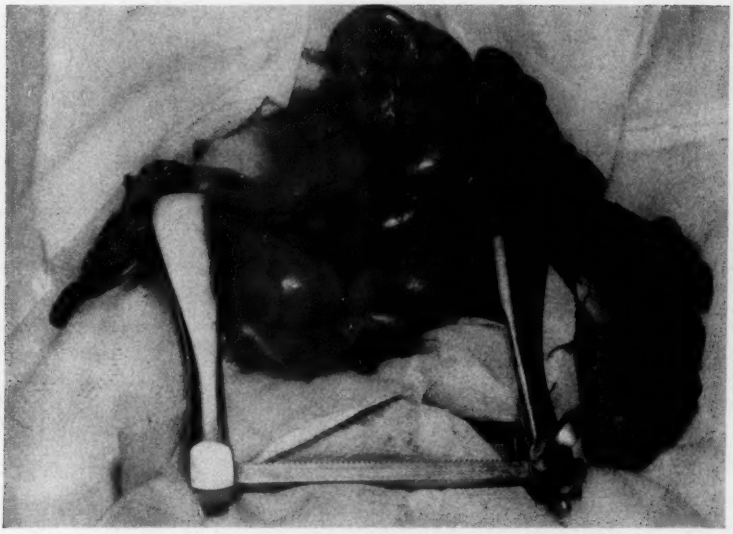

FIG. 2A

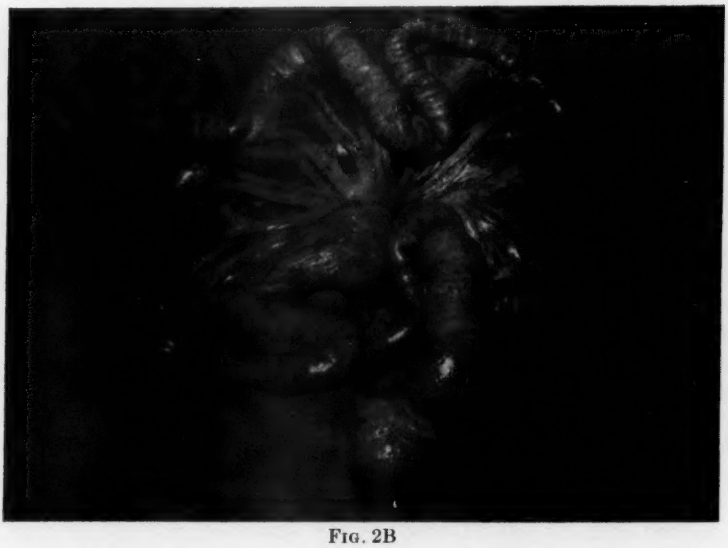

FIG. 2B

FIG. 2. A. Killed 11 days after 500 needle punctures of the abdominal wall, this dog revealed an essentially normal peritoneal cavity. B. Seven days after having 500 needle punctures of the abdominal wall, some very fine, fibrinous adhesions could be felt, but they do not stand out in this photograph.

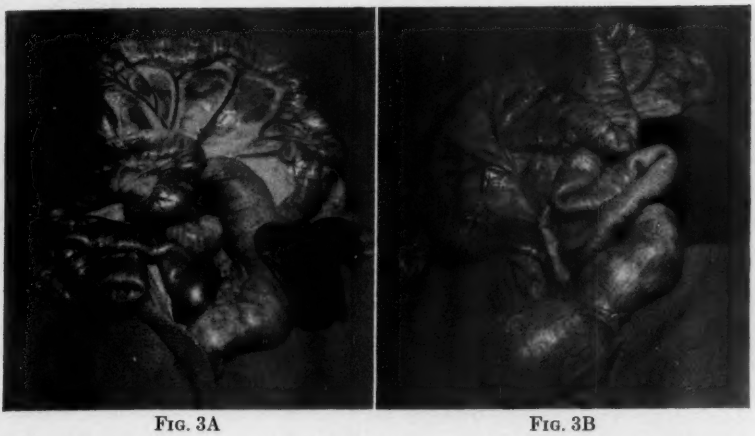

FIG. 3A FIG. 3B

FIG. 3. Three weeks after 250 abdominal wall punctures and 250 direct bowel punctures at laparotomy, these dogs were killed. In A, the abdominal contents are essentially normal. Several adhesions are visible in B, the dog with enteroenterostomy in addition to needle punctures.

viscera were seen, without peritoneal fluid, and without gross adhesions, except in the dog with enteroenterostomy.

Comment on Experiments: These abdominal punctures were made rapidly and at random. We were surprised at the number of apparent intestinal penetrations, amounting to between 5 and 10 per cent of the abdominal punctures. Using moderate care in human beings, this percentage would not be expected to exceed 5 per cent. There was some reaction to the multiple bowel penetrations as evidenced by the occasional slight temperature elevation and the fibrinous adhesions seen early. A very minute amount of peritoneal contamination is to be expected when a needle penetrates a contaminated area (colon) and then is withdrawn. But the insignificance of this amount of contamination is evidenced by the lack of serious reaction to multiple penetrations of all parts of the gastrointestinal tract. In experiment 2, each dog had over 250 bowel punctures. If the danger of a single penetration were appreciable, one certainly would have expected dire consequences, but such did not occur. The important inference to be drawn from these experiments is that, even if the needle used for peritoneal tap does enter the bowel, no significant harm is done.

CLINICAL EXPERIENCE

Our experience with the diagnostic peritoneal tap has extended over a period of 6 years and includes 161 individual procedures. Of this number about 25 per cent were negative taps, no fluid being obtained, of which approximately one fourth were "*false negative*" taps (fluids being present within the abdomen at subsequent laparotomy). The remainder of the negative taps were "*true negative*" taps, the absence of fluid being confirmed by laparotomy or suggested by the

subsequent course of events. The incidence of false negative taps has decreased since beginning the practice of routinely emptying the needle onto a glass slide even though no fluid has entered the syringe. In 8 instances the needle was known to have entered the bowel because of the contents aspirated. Three "*false positive*" taps have been encountered. Two were instances of large extraperitoneal hematomata yielding gross blood in the syringe when no blood existed within the peritoneal cavity proper. The other false positive consisted of fluid being obtained from a large polycystic kidney, no fluid being present in the peritoneal cavity at subsequent operation.

In some instances, the fluid obtained by tap was simply looked at and discarded, the gross appearance having been thought sufficiently characteristic of a condition requiring surgery to require no further examination. In others, more adequate examination was performed and perhaps utilized at the moment but not recorded completely in the patients chart. In 2 patients, the ultimate diagnosis was uncertain and the fluid findings were excluded from this study. Excluding those with uncertain diagnosis, those with insufficient recording of fluid characteristics to be useful and the true negative taps, and adding 17 patients who had no abdominal tap but whose peritoneal fluid was obtained at operation and studied, the peritoneal fluids from a total of 107 patients were utilized in this analysis. Several had fluid removed on more than one occasion, bringing the total number of fluids studied and included in this report to 127.

Complications Encountered: In this series of 161 taps, no serious complication has occurred. The bowel has been entered in 8 patients, the small bowel in 4 and the large bowel in 4. At subsequent exploration, the point of penetration could not be found and there was no evidence of leakage. In no instance was the procedure thought to have been detrimental to the patient.

Site of Tap: We have elected to insert the needle near, but not directly into the area of suspected pathology, usually preferring the middle or lower quadrants on either side, avoiding the course of the inferior epigastric vessels and the solid structures (kidneys, spleen and liver). The midline is sometimes used, but if the lower midline is elected, the bladder should be emptied previously. Previous operative scars are avoided, since the bowel may be adherent to the abdominal wall in these areas. Marked intestinal obstruction may be a relative contraindication to peritoneal tap, but the importance of the information to be obtained often outweighs the possible danger, leading us to use it freely in such instances with no known complications to date. The chief danger here is not the entrance of the needle into the bowel but that the intraluminal contents then aspirated may be mistaken for free peritoneal fluid and be misinterpreted.

Technic: The elected site is prepared in any acceptable manner, but no drapes or sterile gloves are required. Any sterile, no. 18 to 20 gauge needle can be used, but a 2 inch long, short-bevel, spinal needle with stylet is preferred. A needle with stylet is preferred while being inserted to prevent plugging of the needle with fat and to prevent blood from entering the needle while it traverses the abdominal wall. No anesthesia is necessary, although occasionally the skin is anesthetized with 1 per cent Procaine hydrochloride. The needle, preferably with stylet in place, is inserted perpendicular to the skin surface until its point

is thought to be just within the peritoneal cavity. A "*snap*" or "*give*" usually can be felt as the needle passes the anterior muscular fascia and another as it passes the posterior muscular fascia. The peritoneal layer may sometimes be felt as a separate, less pronounced "*snap*".

Holding the needle in place, the stylet is removed and a 10 cc. syringe attached. *Gentle* suction is applied and, if fluid flows easily, the syringe is filled and the needle withdrawn. If fluid is not obtained easily, then the position of the needle is changed by inserting it further, withdrawing it slightly, rotating it or slanting it so that its point is thought to be just beneath the parietal peritoneum. Gentle suction, intermittently, usually will yield at least a few drops of fluid if any appreciable amount is present. Even if no fluid enters the syringe, the needle should always be emptied onto a clean glass slide for microscopic study, since frequently what would otherwise be thought a negative tap will reveal valuable information.

Examination of the Fluid: How the fluid is to be examined depends to large extent upon the quantity of fluid obtained. If only a drop or two is obtained, its gross appearance and odor should be noted and then it should be examined microscopically. A fresh smear, Wright's stain preparation and a Gram stain preparation should be routine. If more fluid is obtained, its pH is determined with nitrazine paper and its amylase content should be determined. The fluid should be cultured. A count of white and red blood cells is frequently helpful.

In practice, the gross characteristics of the fluid frequently dictates the need for, or lack of need for, further fluid studies. For example, if the patient has bowel obstruction, grossly bloody fluid indicates strangulation and no further fluid examination is required. Of if frankly purulent fluid is obtained in a patient with suspected peritonitis, this information alone establishes the presence of peritonitis, obviating the necessity for further fluid studies. But particularly when the gross characteristics are not typical of the suspected disease, more studies are frequently rewarding.

CHARACTERISTICS OF FLUID ASSOCIATED WITH VARIOUS DIAGNOSES

It was hoped that certain easily discernible features of the peritoneal fluid would be of great help in differentiating between the various forms of acute surgical diseases of the abdomen, and in separating this group of diseases from the "*medical*" causes of abdominal pain. For purposes of comparison, the patients have been separated into several groups (table I) and the fluid findings in each group will be presented separately.

Perforated Stomach or Duodenum: Each of these patients, with the lone exception of a perforated gastric carcinoma, had a perforated peptic ulcer. Most of the fluids were turbid and yellow, green or brown. Occasionally food particles could be seen. Rarely bloody or purulent fluid was present. The pH ranged between 5.0 and 8.3 most being between 7.0 and 7.5. On smears, 11 had many polymorphonuclear cells, some had a few red blood cells and some had bacteria. Of particular interest was the greatly increased fluid amylase activity, whereas the blood amylase was normal or only slightly elevated.

Accurate white blood cell counts were done on the fluid of only 4 patients,

TABLE I

Diagnoses in 107 patients whose peritoneal fluids were studied

	Number of Patients
Perforation of Stomach or Duodenum	25
Intestinal Obstruction	24
Acute Appendicitis	6
Acute Appendicitis with Perforation	11
Intra-abdominal Hemorrhage	11
Acute Pancreatitis	8
Acute Cholecystitis	4
Peritonitis, Miscellaneous Causes	8
Nonsurgical Diseases	10
Total	107

ranging between 4,000 and 85,000 per cu. mm. with 90 to 95 per cent polymorphonuclear cells. No free acid was present in any fluid tested and the combined acid varied from 4 to 25 units.

Intestinal Obstruction: The 24 patients with small bowel obstruction included 7 with mesenteric thrombosis, 4 with volvulus, 3 with external hernia, 8 about adhesions, 1 secondary to carcinoma and 1 with paralytic ileus. The fluid findings were very helpful in detecting strangulation, the degree of circulatory embarrassment coinciding well with the amount of blood in the fluid. In general, early strangulation was associated with serosanguinous fluid, although in some the fluid was yellow and contained few, if any, erythrocytes. Grossly bloody, dark reddish-brown and foul fluid was associated with advanced or late strangulation, usually with gangrene of the bowel. In one very late case, dark brown, foul pus was seen. Dark brown and foul fluids usually contained many leukocytes and many bacteria. Leukocytes, uniformly present, ranged from few to over 100,000 per cu. mm. In 2 obstructed patients the needle entered the bowel lumen with no apparent harm. Clear, straw-colored fluid containing no erythrocytes was present in several patients with moderately severe obstruction but without obvious strangulation.

Acute Appendicitis: Six patients with acute appendicitis, not perforated, showed fluid described as milky, yellow or as "*pus*". Characteristically many leukocytes were present, with a high percentage of polymorphonuclear cells. Cultures were negative and erythrocytes usually were absent.

Perforation of the appendix had occurred in 11 patients. The fluids grossly resembled pus of various hues including yellow, green and brown, and some had a fecal odor. Fresh smears were loaded with polymorphonuclear leukocytes and gram stains, when done, usually revealed gram negative rods and gram positive cocci.

Intraperitoneal Hemorrhage: Excluding the bloody fluids associated with intestinal obstruction, pancreatitis and carcinomatosis, there were 11 patients whose peritoneal fluids were notable because of their red blood cell content.

Following trauma to the abdomen or chest, 4 patients yielded fluid by aspiration resembling *"whole blood"* and one yielded serosanguinous fluid. The *"whole blood"* was the result of a ruptured spleen in 2 instances (one combined with a ruptured liver); a ruptured kidney; and a ruptured gastroepiploic artery. The serosanguinous fluid resulted from contusion of the pancreas with a hematoma of the head of the pancreas.

Six patients yielding *"whole blood"* had no history of trauma. In each of 4 young women the cause was a ruptured ectopic pregnancy. In an 87 year old man a ruptured iliac aneurysm was found and in a 58 year old man, whose most strenuous recent activity had been to turn over quickly in bed, the pathology found at operation was a ruptured spleen.

Acute Pancreatitis: The fluids of 8 patients with acute pancreatitis have been examined. These varied between reddish-brown in the more severe cases, to serosanguinous, turbid-yellow and *"milky"* in the less severe. Erythrocytes were usually, but not always, present. Many polymorphonuclear cells were the rule and bacteria were seen occasionally. Of particular note was the consistently elevated amylase activity ranging between 3 and 11 times the normal serum amylase content. The amylase was consistently less elevated in the blood serum than in the peritoneal fluid.

Acute Cholecystitis: Several true negative taps were obtained in patients with acute cholecystitis, and in only 4 instances was fluid obtained for study. Two were perforated, one showing *"thick pus"* with many polymorphonuclear cells and no bacteria on smear, the other yielding only a few drops of fluid containing many leukocytes, erythrocytes and Gram-positive cocci. In the 2 with acute cholecystitis without perforation, one was turbid yellow and loaded with polymorphonuclear leukocytes, the other was light green containing 27,000 leukocytes per cu. mm. (96 per cent segmented).

Peritonitis, Miscellaneous Causes

1. *Perforation of large bowel.* Three such patients had turbid and foul, greenish, yellowish, or sanquinous fluid loaded with polymorphonuclear cells and many bacteria of various forms.

2. *Perforation of small bowel.* Each of 2 patients exhibited opaque, yellowish to brown fluid containing many segmented leukocytes and some bacteria, although less numerous than with large bowel leak.

3. *Leak of Gastroenterostomy.* This patient developed opaque, green peritoneal fluid containing many leukocytes (85 per cent segmented forms) and a few erythrocytes and bacteria, with a slightly acid reaction.

4. *Tuberculous Peritonitis.* This young lady had peritoneal fluid withdrawn and studied on 3 occasions over a 10 day period, the diagnosis being confirmed at laparotomy. The fluid was consistently yellow and only slightly turbid with neutral pH and normal amylase content. The striking finding of the fluid was the leukocyte counts of 750 to 1,200 per cu. mm. with 90 per cent lymphocytes and 6 to 8 per cent monocytes. From 2,600 to 4,600 erythrocytes were present, but no bacteria could be seen.

5. *Pelvic Peritonitis (? Gonorrhea).* The serous, cloudy fluid from this young woman was loaded with polymorphonuclear leukocytes but it contained no bacteria.

Diseases to be Differentiated From Surgical Emergencies

1. *Acute Rheumatic Fever.* This young girl was thought to have acute appendicitis in addition to acute rheumatic fever. A peritoneal tap revealed 2 drops of "*milky*" fluid containing many lymphocytes, an occasional polymorphonuclear leukocyte and no bacteria. Largely on the basis of the many lymphocytes on the smear, operation was avoided. The clinical course supported the diagnosis of serositis associated with acute rheumatic fever.

2. *Gastroenteritis.* This patient, explored for a possible perforated ulcer, had yielded, on tap, a single drop of fluid containing an occasional epithelioid cell but no leukocytes or bacteria. This finding may not be typical of other patients with severe gastroenteritis.

3. *Ulcerative Colitis, Acute.* Fluid obtained by paracentesis from this individual was serosanguinous, with neutral pH and normal amylase content, containing 120,000 erythrocytes and 400 leukocytes (67 per cent segmented) per cu. mm. with no bacteria. Her clinical picture was that of small bowel obstruction, but on exploration, acute ulcerative colitis and an associated ileus was found. The fluid findings in this instance were misinterpreted.

4. *Ascites.* Two patients had studies, incomplete, of their ascitic fluid. It was clear yellow and contained "*essentially no cells*" in one and a moderate number of leukocytes in the other. Other ascitic fluids, not included in this study, have contained more leukocytes, not predominantly polymorphonuclear cells, and few to many erythrocytes.

5. *Typhoid Fever.* A 28 year old, Negro girl had fever and ileus suggesting partial small bowel obstruction. Peritoneal fluid was cloudy and serous and contained 3,500 leukocytes per cu. mm., 67 per cent of which were lymphocytes and 6 per cent were monocytes. At exploration more fluid and enlarged mesenteric nodes were found. Cultures of the fluid were negative. Positive typhoid agglutinations and her subsequent course led us to believe that she had typhoid fever and that the peritoneal fluid occurred on that basis.

6. *Carcinomatosis.* The 4 patients in this group had fluids ranging from straw-colored to grossly bloody, each containing red blood cells, usually in large numbers. Leukocytes also were present in each, but without a high percentage of polymorphonuclear cells. Carcinoma cells were seen in one.

DISCUSSION

The diagnostic peritoneal tap has proved to be most useful in the acutely ill in whom the need for surgery is not clear. It is particularly valuable in the two extremes of life, since the history so often is inadequate in the young and the disease so often is atypical in the aged. We have used the procedure more liberally than is necessary, in order to learn the significance of the various fluid characteristics.

The danger associated with inserting a needle through the abdominal wall into the peritoneal cavity is so slight that, in our opinion, it can be ignored.

Interpretation of Fluid Characteristics: Of greatest importance is a correct interpretation of the findings obtained through a study of the peritoneal fluid. Although much is still to be learned about the meaning of these findings, enough is now known to justify some general statements concerning their significance.

Purulent Fluid: The presence of pus, free in the peritoneal cavity, means peritonitis. Most, with the exception of those with primary peritonitis, probably are best treated by operation. The value of studying a smear of the peritoneal fluid in the diagnosis of primary peritonitis has been emphasized by Neuhof and Cohen[10], Denzer[4], Campbell[1], and Steinberg[12]. The presence on smear of large numbers of pneumococci, streptococci, or gonococci are characteristic of pneumococcic, streptococcic or gonococcic forms of primary peritonitis. Whereas, the presence of many gram-negative rods, with or without a few cocci means that the peritonitis probably is of the *"secondary"* type, usually due to a ruptured appendix. Unstained, fresh smears reveal very large numbers of leukocytes, with a high percentage of polymorphonuclear cells.

"Bloody" Fluid: These fluids vary from "serosanguinous" to *"whole blood"* in appearance. Not included in this type of fluid is the *"bloody tap"*, by which is meant that a drop or two of blood entered the needle as it traversed the abdominal wall. A *"bloody tap"* has no significance, since if there is an appreciable amount of blood within the peritoneal cavity, a free flow of blood into the syringe usually results. Of some help in differentiating intraperitoneal blood from a *"bloody"* tap is the decreased tendency of blood from the peritoneal cavity to clot.

The significance of grossly bloody fluid within the peritoneal cavity depends to some extent upon the patients clinical history, but, with the exception of acute pancreatitis and carcinomatosis, most entities associated with grossly bloody fluid are best treated by operation. In a young woman of child-bearing age, a ruptured tubal pregnancy is suggested. In those who have been subjected to trauma to their abdomen or chest wall, a ruptured spleen, liver or kidney is likely. With intestinal obstruction, grossly bloody fluid strongly suggests serious strangulation and the need for early operation, and the presence of many erythrocytes, in fluid not grossly bloody, has a similar significance.

Microscopic Examination: Unless the fluid is purulent or grossly bloody, a careful microscopic examination is mandatory in order to profit most from what the fluid has to offer. Greenish, brown, yellow, and milky fluid may be associated with various diseases, and these colors have little significance in themselves.

The scarcity or abundance of leukocytes, the leukocyte differential, and the number and kind of bacteria present in such fluid can be most helpful.

Many leukocytes usually are present in all fluids resulting from acute inflammatory or contaminating insults, such as appendicitis or perforated ulcer. In these instances, there is a high percentage of polymorphonuclear cells with few lymphocytes. On the other hand, although a moderate number of leukocytes may be present with such milder inflammatory lesions as tuberculous peritonitis

and the serositis associated with rheumatic fever, the percentage of lymphocytes is high.

The microscopic findings with a ruptured appendix may be like that of an unruptured acute appendicitis except that many organisms usually are seen on gram stain if rupture has occurred. Bacteria usually are present with peritonitis but not with an unruptured acute inflammatory process. The occasional help in differentiating between the primary and secondary types of peritonitis has been discussed earlier.

Microscopic examination is invaluable in differentiating peritoneal fluid from bowel contents, since the gross appearances may be similar. They differ microscopically in that leukocytes, which are so numerous in peritoneal fluids, are absent in bowel contents as a rule. Vegetable matter, present in the bowel, usually is lacking in peritoneal fluids, and colon contents contain more bacteria.

Acidity: We had hoped that acid entering the peritoneal cavity from perforated ulcers usually would be detectable as such and thus be of great help in differential diagnosis. Such is not the case. Rarely has fluid with an acid reaction been found, most fluids being neutral or slightly alkaline. However, when encountered, a pH of 6.0 or less is good evidence of a widely open, perforated ulcer.

Amylase: The amylase content of the peritoneal fluid has been of considerable interest and help. It is markedly elevated in pancreatitis and in any leak from the upper gastrointestinal tract. In each of these situations the peritoneal fluid amylase is consistently more elevated than is the blood serum amylase. Our findings in this regard coincide with those of Keith, Zollinger and McCleary[7], Howard[6] and Pemberton, Grindlay and Bollman[11]. It has proved useful in differentiating acute pancreatitis from perforated ulcer. In each the peritoneal fluid amylase is markedly elevated, but, at least in our cases, the blood amylase has been much less elevated with perforated ulcer than with acute pancreatitis in its early phase. It is common to find the peritoneal fluid amylase still markedly elevated 2 or 3 days after the blood amylase has returned to normal in patients with pancreatitis.

The Negative Tap: To use the diagnostic peritoneal tap safely, it is imperative to realize that a negative tap means only that no fluid was obtained and not that no fluid was present in the peritoneal cavity. If, clinically, exploration is clearly indicated, the mere fact that no fluid was obtained by tap should never prevent operation. The negative tap is of some value in giving reassurance when we already are inclined not to operate. False negative taps have occurred in about 6 per cent of this series. Although this incidence has been reduced considerably by routinely emptying the needle contents onto a glass slide when no fluid reaches the syringe, the occasional false negative tap which still occurs necessitates our present opinion regarding its interpretation. This opinion is in contrast to that expressed by Thompson and Brown[3], but is in agreement with the opinions expressed by Neuhof and Cohen and Denzer.

SUMMARY AND CONCLUSIONS

The diagnostic peritoneal tap often is of great value in determining the need for laparotomy in patients with acute abdominal disease. Its general acceptance has

been retarded because of the prevalent fear of inserting a needle into the abdomen. That this fear is unwarranted is indicated by the absence of complications in large series of abdominal paracenteses. Only rarely will a needle entering the abdominal cavity enter a loop of bowel, and our experiments and others demonstrate the innocuousness of this incident. No complications were encountered in this clinical experience with 161 peritoneal taps.

A summation of the characteristics of the peritoneal fluids associated with various surgical and nonsurgical diseases of the abdomen is given from a study of 127 such fluids.

The significance of various peritoneal fluid characteristics is discussed from the standpoint of differential diagnosis.

In our opinion, the diagnostic peritoneal tap is a safe and valuable aid in the diagnosis of acute intra-abdominal disease. Its value and safety, together with its simplicity, warrant its general acceptance and frequent use.

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ACUTE SPINAL INJURIES

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Spinal injury occurs frequently in association with injuries elsewhere in the body. A common source of these multiple-injury cases is the automobile accident. Of 176 patients with cases of fracture of the spine admitted to the Baptist Hospital (Memphis) over a 5 year period, approximately 30 per cent resulted from automobile collisions. Evaluation in the emergency room of the patient with multiple injuries is difficult at best.

No attempt is being made to minimize the necessary attention to other injuries. Establishing a free airway and treatment of shock always merit first consideration.

Evaluation of the extent and degree of injuries is the next logical step. Here the examining physician should consider the possibility of an injury to the spine. Such injury is likely overlooked unless the patient is complaining of pain about the spine or unless obvious paralysis exists. Attention is directed in this treatise to the recognition and immediate management when spinal injury is present.

In addition to localizing the area of tenderness and maximal pain over the spine, a simple but adequate examination for gross neurologic function should be routine. This includes: (1) Test for movement and muscle strength in the extremities. (2) Test for sensation by touch and pin prick. (3) Test for rectal sphincter tone and control by digital examination.

The use of these tests, which require no special instruments or specific skill, will eliminate pitfalls that obscure the true nature of the lesion.

Pain in the low back with radiation of the pain around the abdomen suggests fracture of the lower thoracic spine with nerve root irritation. In such a case an injury to the conus medullaris or end of spinal cord can be overlooked. This structure is anatomically located adjacent to vertebral bodies, thoracic 12 and lumbar 1. Injury at this level may not impair movement of the lower extremities, and the neural damage becomes apparent only when rectal sphinter control and saddle area sensation are examined.

A similar pitfall is present when the injured patient can move his arms but not his legs. In such a case sensation may be lost up to the nipple line. This sensory level may suggest that the spinal injury is at the third or fourth thoracic level. Routine examination of strength and sensation in the upper extremities, even when the patient can move his arms, is necessary. The partial impairment of function in the hands and arms will localize the lesion at a higher level (cervical). Thus, the cutaneous innervation of the upper chest by the cervical plexus of nerves gives rise to this false localizing segmental level.

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If the tests reveal no impairment of sensory or motor function; sprain, disk rupture, or fracture without neural impairment may be the problem at hand. The examination supplemented by roentgenograms usually reveals the type of spinal injury. Noteworthy is the fact that *fair* roentgenograms are useful in diagnosis, but *excellent* roentgenograms are necessary to decide management. Additional information is obtained from special views. An oblique view may aid in finding a fracture of the facet. A magnified view may disclose a fracture of the body that is difficult to establish on routine roentgenogram.

Sprains and intervertebral disk rupture occur principally in low back and cervical regions. Traumatic disk ruptures resulting from automobile accidents have been rare in the cervical region, and sprains have been frequent. Localized pain, tenderness, associative muscle spasm, and limitation of motion of the segment of the spine involved, characterize both the sprain and the disk rupture. Roentgenograms are negative for fracture. In addition to these mutual symptoms and signs disk rupture usually has accompanying signs of nerve root irritation with radiation of pain along the course of the nerve.

Treatment of a sprain and a rupture intervertebral disk is the same unless signs of nerve root impairment develop in the latter condition. In this case surgical removal of the insulting disk is advisable. Otherwise conservative treatment with absolute rest, restriction of motion, and local heat, is prescribed. Traction often is a necessary adjunct to treatment aiding in restricing movement and relieving muscle spasm.

Fracture of the spine without accompanying neural damage presents several problems depending principally upon what part or parts of the vertebrae are involved.

Fracture of a transverse process might occur singularly in the lumbar spine. This injury is exceedingly painful. The location of the tenderness and muscle spasm might confuse the injury with rupture of a kidney.

If the initial roentgenograms do not reveal the fracture, subsequent roentgenograms are advisable and usually will verify the clinical impression.

Fracture of spinous processes is not a serious injury in itself. Little pain or difficulty is expected in the thoracic and lumbar regions. This injury in the cervical region is more significant. Pain and muscle spasm are marked and recovery is prolonged.

These fractures of the transverse and spinal processes are treated by immobilization during the painful period. Surgical intervention, such as removal of the spinous processes, seldom is indicated. Spinal fracture involving the other parts of the vertebrae, such as facet, pedicle, and lamina is of a more serious nature than fracture of the processes mentioned above. Compression fracture of the vertebral body results from indirect trauma, as is the case in the "jackknifing" injury, or when the insulting force is applied to either end of the spine, i.e., head or buttocks. Subluxation or dislocation of the vertebral bodies occurs when the pedicles and facets are deranged. Neural injury is frequent in this latter group.

Any study of a series of spinal injuries reveals that by far the majority of frac-

tures occur at two principal locations—the lower cervical and the dorsolumbar. These two mobile areas, adjacent to the stable thoracic spine with its supporting rib cage, bear the brunt of any indirect or flexing force. In the automobile accident group, 60 per cent of the patients had their fracture in the cervical region and 30 per cent in the dorsolumbar junction area, i.e., D-12 and/or L-1.

Since the frequency of cervical injury is apparent, further mention of the handling of such cases is justified. Confronted with a patient with a probable fracture-dislocation of the cervical spine, we are aware that each time this patient is turned, moved, or transferred to another stretcher or table, permanent, irreparable damage to the spinal cord can occur. With this thought in the minds of all attendants (doctors, technicians and nurses) roentgenograms of the cervical spine are taken. All cervical vertebrae must be visualized. The difficulty encountered in obtaining the seventh cervical vertebra on the lateral view must be overcome by angulation of the X-ray tube or by traction on the shoulders. If the suspected fracture is not found on this initial roentgenologic study, do not attempt at this time flexion or extension views of the cervical spine.

On finding the fracture of the cervical spine in the patient without neural damage, head traction is applied with Crutchfield tongs or with a similar apparatus. With the traction effecting the proper pull, no further immediate treatment is needed. During the course that follows, the decisions regarding need for open reduction and/or fusion can be made.

In the absence of neural damage, the majority of fractures of the dorsolumbar spine are handled by the simple hyperextension methods. A delay of 4 to 5 days is advised before reduction is effected. Detailed roentgenologic examination is necessary before the procedure. Fracture of the facets and adjacent laminae or pedicles must be ruled out. Fracture of these posterior parts is the danger signal contraindicating closed reduction methods.

Fracture of the spine with neural damage is indeed a different problem. The presence of spinal cord injury with paralysis below the cervical level demands prompt attention in the care of the handicapped respiratory, gastrointestinal and urinary systems in addition to application of head traction. The diaphragm and accessory cervical respiratory muscles cannot clear the respiratory tree of pooling secretion. Aeration is diminished and the patient's struggle for air is apparent. Tracheostomy, thus, is stressed as a necessity in the early or immediate treatment phase. Paralytic ileus with distention is always present and continuous for 2 to 3 days until autonomic activity is resumed. Continuous gastric aspiration with Wangensteen suction is indicated. The early insertion of a urinary catheter is always mandatory and will prevent the complication that arises from overdistention of the paralyzed urinary bladder.

Treatment required now of the compression or contusion of the spinal cord necessitates the specialist's opinion. Difference of opinion still prevails among neurosurgeons as to when laminectomy is indicated. Most might agree with this dictum. With the paralysis progressing, laminectomy is necessary and becomes an emergency procedure. In cases of incomplete paralysis associated with moderate or severe bony deformity, laminectomy is the wise choice. Complete paraplegia

with spinal fluid block prompts laminectomy unless the bony deformity is extreme. The question of surgical exploration in all other patients that are not demonstrating improvement can only be dealt with on an individual basis.

When neural injury occurs in fractures of the dorsolumbar area, nerve root pain is a dominant symptom and one difficult to relieve. Voluntary rectal sphincter control is lost, and accompanying sensory disturbances in the saddle area may be present.

Laminectomy is advisable in most of these patients. The procedure is advocated if a spinal fluid block is present or if open reduction of the fracture is necessary. Intractable nerve root pain and myelographic defect at the level of injury justify the surgical procedure. Extrusion or rupture of the intervertebral disk is not an uncommon finding in association with fracture at this level.

The group of cases of *neural damage without fracture* are appropriately termed spinal cord concussion. However, the persistence of neurologic impairment beyond a several-day period is evidence of more permanent injury. That many cases of mild spinal cord concussion are overlooked is logical to assume. The history of temporary loss of use of the extremities is not as striking as the history of unconsciousness in cerebral concussion. The phrase *"paralyzed for a second"* used by the patient in describing the shock of an accident may have more meaning than to indicate one has been *"scared stiff"* in fright.

Spinal cord concussion has been defined as a transient, reversible physiologic dysfunction manifested by paresthesia, weakness, abdominal rigidity, urinary retention and reflex changes. It is possible and probable that a brief or momentary period of paralysis precedes the above characteristics.

Rigidity of the abdomen and transient quiescence of the bowel, the alert signal for possible abdominal viscus or organ rupture, creates concern. Differential diagnosis is not too troublesome provided the possibility of spinal cord concussion is given consideration. The other accompanying neurologic symptoms and signs disclosed on neurologic examination are usually sufficient to clarify the diagnosis.

Penetrating injuries to the spine which are infrequent in civilian life should be mentioned to complete the classification of spinal injuries.

SUMMARY

Evaluation of a patient with multiple injuries demands consideration of the spine. The examining physician with an awareness of the types of possible injury to the spine can recognize such by a simple, brief neurologic examination supported by adequate roentgenologic studies. Attention should also be directed to the proper immediate treatment of these acute spinal injuries.

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THE UROLOGIC SIGNIFICANCE OF IMPERFORATE ANUS

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Anorectal anomalies, for which the empirically generic term imperforate anus may serve, occur with a frequency ascribed as somewhere between 1 in 1000 and 1 in 5000 births. Although a tendency toward multiplicity in congenital anomalies has long been recognized, few entities are so often accompanied by other congenital difficulties. This frequent occurrence seriously compromises the over-all prognosis, even in instances where the anorectal problem has been dealt with satisfactorily, and has been responsible for approximately one-half of the deaths. The gravity of the imperforate anus problem is perhaps exemplified even further when one considers the extremely high nonsurgical mortality rate.

The classification of anorectal anomalies promulgated by Ladd and Gross has become rather generally accepted, since its simplicity is a blessing in a field where minor variations are so rampant. Ladd and Gross stylize type one as a stenotic narrowing of the rectum or anus. In type two, the rectal pouch is quite low; while in type three, several centimeters may separate the blind ending rectal pouch from the anus. The rectal atresia of type four, is associated with a normal appearing anus and lower rectum. In relation to concomitant anomalies it has been noted that their occurrence is much more frequent in types three and four. It should be clarified that congenital fistulous communications, urinary or genital, are not described as separate or additional abnormalities, since they are more properly classified as an integral part of the anorectal malformation.

Analysis of coexisting anomalies reveals that the urinary tract is reputedly the most frequently involved. Hydroureter and hydronephrosis are the most common findings, followed by renal hypoplasia, or aplasia, hypospadias and exstrophy of the bladder. The next most frequently involved is the vertebral-neurologic system. Lumbar and sacral vertebral deformities are commonly seen. Congenital heart disease of varying types is quite common and in the alimentary tract, atresias are found with a high degree of frequency.

The frequency with which fistulous communications between the rectum and the urinary tract or the vagina have been described has increased almost invariably, with each subsequent review of collected cases. The over-all incidence of such fistulas in the total group of anorectal malformations is believed to be upwards of 80 per cent. A certain number of these anorectal malformations are of a minor sort, merely a stricturing of the anal opening or a spontaneously or easily ruptured anal membrane; if these are eliminated from the total, one would then estimate that the cocurrence of fistulas in the remainder must be of an even greater frequency, possibly in excess of 90 per cent.

A brief review of the derivative embryology of the anorectal region might be

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helpful in understanding the reason for such a plethora of malformations. In early embryonic life the urinary tract and the lower part of the intestine are actually one cavity, the cloaca. This cavity becomes divided into anterior and posterior portions with the intrusion of the urogenital membrane, which separates the future urinary bladder from the primitive rectum. Normally the embryonic rectum then descends toward the perineum, where an infolding of ectoderm is met, and thus the rectum joins the anal canal. Malformations in this area, especially in relation to fistulous communication between the rectum and the urinary tract, are more easily understood when one realizes additionally that the development of the Wolffian ducts (subsequently the prostatic urethra and ureters) is so intertwined embryologically. The interpolation of such a duct system, with potential digressions from the normal rotational-absorption of its components into the future bladder and posterior urethra, is permissive of a variety of hind gut contact and adherence, allowing the rationale of the variation of position of fistulous tracts to become more apparent. In the female the interposition of the Muellerian duct system fosters the absorption of the majority of fistulous communications into the future vagina rather than into the bladder or urethra. Specifically, anorectal malformations are due to failure of the proctodeum to meet and properly unite with the primitive rectum. A carry over of a process seen frequently in the upper alimentary tract in all probability may obtain in some instances of anorectal-atresia and stenosis. This refers to a process which occurs during the development of the intestines, when the intraluminal rapidity of mucosal growth outstrips the increase in the caliber of the tube concerned. If the normal rapid readjustment of the caliber of the intestinal tube does not occur, atresia and stenosis can ostensibly develop on this basis.

In respect to the urinary tract the sites of fistulous communication may vary markedly. The most common juncture is a urethrorectal fistula. This occurs almost exclusively above the level of the external urethral sphincter in the male, commonly in the immediate vicinity of the verumontanum. Vesical fistulas are not so common as the urethral type, but can occur, and in almost any area of the bladder base or posterior wall. As would be expected from the embryologic mechanisms involved, vesicouretero-rectal fistulas have been annotated. In the more complex forms of anomalous development of the lower alimentary and urinary tracts many bizarre and severe complications may present themselves, defying their inclusion in any categorized classification.

The urologic survey which should be done in these patients is simple and can be accomplished in a short period of time. In some instances the presence of a patent rectourinary tract fistula can be concluded from the history, if it has been noted that fecal material has been passed per urethram; however, the presence of a satisfactory urinary stream and the absence of fecal contaminants in no way guarantees the absence of a fistula. In the female the presence of a rectovaginal fistula does not negate the possibility of a concomitant rectovesical or rectoureteral fistula.

If the condition of the patient warrants any delay in surgical intervention, the complete urologic survey is warranted equally as well.

With the recent availability of indwelling catheters of a size as small as 8 French, even the newborn male urethra can accommodate such a catheter for diagnostic purposes as well as to facilitate surgical dissection and repair of such fistulous communications as may exist. Catheterization then is the first step in the investigation. Subsequent to evacuation of urine and its analysis, X-ray films taken in the 15 minute, inverted position, for estimation of the distance between the blind rectal termination and the perineal dimple are secured. Anteroposterior oblique and lateral cystographic views are then made and followed by a voiding urethrogram which can readily be obtained if sufficient radiopaque material is placed in the bladder. These studies will serve to demonstrate any large deficiencies or fistulous communications and also will make apparent any accompanying vesical or urethral abnormality. Delayed cystograms should be secured in order that upper tract abnormality may be delineated, either as a ureterovesico-rectal fistula or perhaps with the appearance of ureteral reflux.

If there exists an actual impediment to the passage of the catheter one may construe this as indicative of some congenital anomaly usually of an obstructive nature. Such obstructions, in the prostatic urethra, at the bladder neck and less frequently in the distal urethra, have been seen to occur, and of course mandate suprapubic cystostomy at the time of the corrective surgery, should the degree of obstruction warrant it.

Although there has been some reluctance to carry out excretory urography in newborn infants, there is very little evidence to the effect that it is in any way detrimental to the child. Twelve or 15 cc. of any of the urographic media can be given and in most instances films satisfactory for all but the finer points of architectural delineation, can be obtained. Thus in the period of an hour or two a relatively complete urologic examination can be accomplished. Infrequently will urethrocystoscopy be necessary, but should the condition of the child be permissive, it can be consummated under the same anaesthesia utilized for the intestinal surgery.

The greater proportion of upper urinary tract pathology encountered in association with anorectal anomalies will be such that corrective procedures can be carried out subsequent to the establishment of a proper alimentary canal.

In the management of the urinary fistula it would seem reasonable that whether one can demonstrate a patent communication or not the probability of its existence is great. Surgical procedures thus should be designed to clearly expose the area of the posterior urethra and bladder in order that such communications may be cleanly severed and properly closed, assuring that distortion will be avoided and scarring minimized. It has been shown that the frequency of disruption of fistula repair is greatest, secondary to exclusively perineal exploration, and particularly so when the fistulous tract communicates with a high lying rectal pouch. Reinstitution of the urinary fistula subsequent to perineal proctoplasty poses a serious problem from both the urologic and proctologic aspects. The vesicorectal and especially the urethrorectal septal areas become greatly scarred, frequently distorted, and often lacking in definable planes of cleavage. Subsequent reparative procedures may jeopardize both urinary and fecal con-

tinence for two reasons. The majority of the urinary ostia of these fistulas are in the posterior urethra where the mechanism of urinary continence derives. Secondary dissections thus are prone to deprive the individual of continence on the one hand, or be productive of stricture secondary to exuberant scarring on the other; hardly desirable alternatives. Recurring assaults on the external anal sphincter in an attempt to satisfactorily mobilize the bowel and allow proper separation and closure of the fistula run the hazard of producing a functionless or strictured external anal sphincter. Each subsequent surgical failure multiplies the possibility of such morbidity.

Many difficulties have been seen to occur subsequent to preliminary colostomy in the management of these anomalies. Colostomy problems have been of two sorts, proximal loop prolapse or stenosis; and more commonly distal loop exigencies: impaction of feces, barium concretions, calculi of urinary tract origin, prolapse of the distal loop, or urinary incontinence via the distal loop. It has, therefore, become apparent that neither the perineal approach nor the immediate colostomy is of particular satisfaction in the management of these cases.

Fairly recent experience has demonstrated that the combined abdominoperineal approach is most appropriate—perhaps mandatory—in the management of any but the most trivial of imperforate anus cases since it is permissive of two most important requisites: It allows for adequate mobilization and revision of the colon no matter how high the blind ending lies and has thus the advantage of being complete, competent and constructed without tension. Additionally, and perhaps of more importance, the area of communication between the rectum, and the bladder, urethra or ureter, may be dissected out, under direct vision, allowing for definitive, enduring plastic repair of such defects.

There are surgeons who state categorically, that in the male where the rectal pouch extends in excess of 2 centimeters from the anal dimple or in any case where a urinary fistula exists, the combined abdomino-perineal operation is the procedure of choice. Not solely because of the difficulties ascribed to the colostomy, nor primarily in regard to the inadequacy of the perineal approach in consummating a satisfactory rectal pull-down, but primarily owing to the fact that the consequences of inadequate surgery in respect to the urinary fistula can be of crippling intensity.

CONCLUSIONS

One can summarize by saying that the initial requisite in the management of anorectal anomalies is primarily diagnostic, in order that the type and extent of intestinal as well as urinary tract anomalies may be fully understood. Then from the standpoint of surgical repair, it would seem that the combined abdominoperineal approach in the majority of these cases, would be the most fortuitous one. This naturally does not mean that preliminary colostomy should never be done, for the extent of the intestinal and urinary tract anomalies can be such that only prolonged investigation can clarify the exact nature and architectural pattern of the anomaly. This is especially true in instances where a persistent urogenital sinus may be associated with marked intestinal malformation, and

multiplicity of anomalies. What should be deprecated in the management of imperforate anus, however, is the prevalence of attempts to repair anorectal anomalies by perineal exploration when the exact status of the urinary tract is unknown and when the surgeon is not certain at what level the bowel lies. We speak of these things with feeling because of the number of exasperating urologic deformities which we have seen and are still seeing in our clinics, the result of poorly diagnosed and poorly planned surgical attacks upon anorectal anomalies.

Between the years 1947 and 1955 there were 40 patients who had imperforate anus admitted to the John Sealy Hospital. Twenty-five males and 15 females. Two of the females were instances of intersex.

Associated anomalies other than fistulas, were found in 3 cases of type one imperforate anus; in 3 cases of type two; in 12 cases of three; and in 8 of type four. Thus 26 of the 40 cases gave evidence of a major concomitant anomaly, the preponderance occurring in types three and four. In respect to the organ systems involved, 14 instances of associated genitourinary anomalies were represented. Nine cases evinced vertebro-neurologic anomalies and 9 presented alimentary tract problems. Cardiac anomalies were seen in 5 cases. Among the 25 males there were 16 verified urinary-intestinal fistulas; 4 others gave strong presumptive evidence of a fistula but for varying reasons remained unproved urographically or surgically. An 80 per cent occurrence of fistula is thus postulated. Most of the communications in the male were urethrorectal; 13 in number, and all in the posterior urethra. There were 2 instances of vesicorectal fistulas and 1 of a ureterovesico-rectal fistula.

That the Muellerian duct system is a most fortuitous buffer toward the obviation of urinary-intestinal fistulas in the female is seen when the proportion of vaginal-colonic communications versus urinary-colonic fistulas is examined. Nine of the 15 females were seen to have rectovaginal fistulas. Of the 4 females designated as evidencing urinary intestinal communications, 2 were cloacal defects, and 2 were intersex problems with urogenital sinuses collecting urine and feces, but no true fistulas.

The problems presented by cases of imperforate anus thus are seen to be frequent, multiple and often complex. More appropriate measures to resolve these problems are sure to follow more widespread reporting of these cases and the manner in which they were handled.

DISCUSSION

May I compliment Doctors Hooks and Thompson on their presentation and mention another complication due to fistulas between the urinary tract and bowel. If urine enters the bowel freely, a metabolic acidosis may occur as happens when the ureters are transplanted into the sigmoid. This physiologic complication frequently is not recognized and may cause serious acid-base imbalance and must be corrected without delay. Often it must be corrected temporarily by establishing free urinary drainage of the bladder.

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URINARY SODIUM AND CHLORIDE DETERMINATIONS AS AN AID IN THE DIAGNOSIS OF ADRENAL CORTICAL INSUFFICIENCY*

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Clinical and experimental evidence for the important role played by the adrenal cortex under conditions of stress focuses attention upon the surgical patient.[6, 10] Of particular concern to the surgeon is the recognition of those patients who might be suffering from adrenocortical insufficiency. Whereas iatrogenic, or corticosteroid-induced, insufficiency has been well documented,[17] patients presumed to be suffering from adrenocortical failure solely as the result of stress, such as trauma, repeated surgical procedures, severe illness, or chronic infection, are less well authenticated. The observation that some patients following extensive surgical procedures fail to progress satisfactorily until corticosteroid therapy is administered suggests adrenocortical failure as the cause.[8, 21] There is, however, a paucity of laboratory evidence to support this concept.[22, 23]

Tests of adrenocortical function, including the water diuresis test, eosinophil response to ACTH or surgical trauma, and the salt excretion test are either impracticable or unreliable.[21] Facilities for quantitative determinations of serum or urinary corticoids are not generally available.[5] Because electrolyte determinations of serum and urine are more readily obtained by simpler laboratory technics, their use has been suggested in selected cases for evaluating the activity of corticosteroids,[12, 15] certain fractions of which are essential to the renal conservation of salt. The critically ill surgical patient presenting a fluid and electrolyte problem may fall into this category. Such a patient, presenting abnormalities of serum and urinary electrolyte patterns consistent with adrenal insufficiency, should be recognized if rational, as opposed to empirical, therapy is to be instituted.

Pertinent to the interpretation of such electrolyte data is an understanding of the renal excretion of electrolytes.

The normal kidney possesses a remarkable compensatory mechanism for excreting sodium and chloride ions.[18, 19, 28] When intake of these ions exceeds losses, including extrarenal losses, the excess is readily excreted in the urine. Such excess will be reflected in an increased concentration of these ions in the daily urine output unless the urinary volume is exceptionally large. Conversely, when intake of salt is less than its loss, renal conservation as reflected in a reduced urinary concentration promptly occurs. Thus a normal urinary concentration of the order of 25 or more mEq. per liter sodium and 25–50 mEq. per liter chloride may drop to 8 or less mEq. per liter when deficits of these ions occur.

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Under stress, which includes the first 24 to 48 hours following surgery, sodium and chloride are conserved regardless of their state of balance within the body prior to surgery.[2, 4] This transitory alteration in the renal excretion of sodium and chloride is attributable to an increased adrenocorticosteroid activity.[27] Renal conservation of salt, reflected in a low urinary salt concentration, represents, then, a response of the normal kidney to either a deficit of these ions or to an increased corticosteroid activity.

This expected renal conservation of salt may fail for any one of the following reasons:

1. Potassium deficit. This condition is characterized chemically by lowered serum levels of potassium, sodium, and chloride and an increased concentration of urinary chloride with an associated alkalosis—so-called hypochloremic alkalosis.[3] Only by correcting the potassium deficit will the ability of the kidney to conserve salt be restored thereby allowing administered salt to be retained by the body for correction of the salt deficit.

2. Renal tubular damage. Since the renal tubules reabsorb salt from the glomerular filtrate, tubular damage from a nephritis may impair this function resulting in a so-called "salt-losing nephritis".[26]

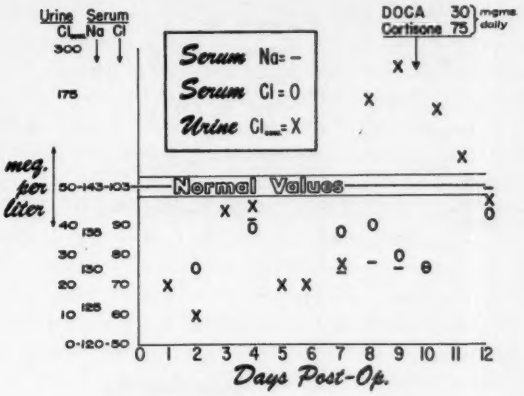
3. Sodium paradox. In some acutely ill patients, notably those suffering acute peritoneal insults, a low serum sodium and chloride is found.[12] These lowered serum levels may be misinterpreted as representing a body deficit of salt whereas actually they result not, as balance studies have shown, from either renal or extrarenal losses, but rather from a change in osmolarity of the blood.[18] Renal conservation of salt is not, in fact, impaired. Attempts, however, to restore to normal the serum levels of sodium and chloride by vigorous salt therapy will result in increased urinary loss without improvement in the serum levels. Return of normal serum levels is dependent upon improvement in the general condition of the patient.

4. Adrenocortical insufficiency. Because renal loss of salt with a resultant salt deficit is characteristic of adrenal failure its occurrence in the surgical patient constitutes suggestive evidence for such a diagnosis.

The differentiation of these four above-mentioned metabolic states, one from the other, requires urinary as well as serum electrolyte determinations. Because many of these problems present serious electrolyte imbalances, such determinations assembled as balance data may be desirable for purposes of quantitative fluid replacement therapy.

Hypochloremic alkalosis usually may be recognized by either a low serum potassium level, typical electrocardiographic changes, or both. The sodium paradox, while not properly belonging to the group of salt-losing disturbances of the kidney, may be confused with them if salt is given in excess of balance requirements in an attempt to correct a low serum salt level; then, or course, high salt concentrations in the urine ensue.

Detection of the sodium paradox is made by demonstrating renal conservation when salt administration is withheld to below balance requirements. If, however, balance requirements are exceeded, a test dose of corticosteroid may be admin-



GRAPH 1. See text for explanation

istered to observe its effect on the serum and urinary levels of salt. A lack of effect distinguishes sodium paradox from adrenal cortical insufficiency. In cases of suspected renal tubular damage, withholding the administration of salt to below balance requirements is ineffectual. Likewise, the administration of corticosteroids is without effect.[12]

The differentiation of suspected adrenal cortical insufficiency from the commonly encountered sodium paradox is demonstrated by the following 2 cases.

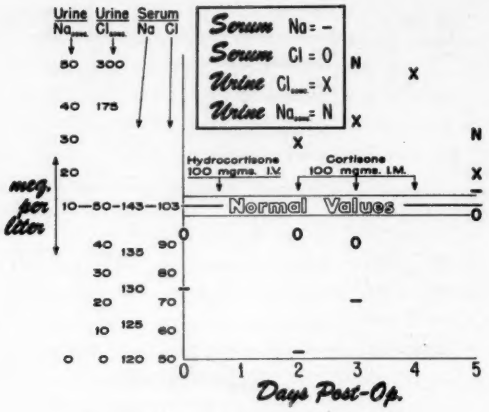
CASE REPORTS

Case I. J.M. This 57 year old white woman was admitted to the hospital on Aug. 1, 1953 with an obstructing carcinoma of the distal transverse colon. A proximal decompressing transverse colostomy was done the same day. Seventeen days later a right hemi- and transverse colectomy with an end to end ileocolostomy was performed. Eight days following this second procedure, she developed an acute condition within her abdomen. Exploration revealed a perforation at the site of the anastomosis. A catheter ileostomy through the site of perforation was fashioned. Her convalescence following this third procedure was satisfactory until the sixth postoperative day when she became mentally confused, lethargic, and hypotensive.

The electrolyte data (graph I) indicates adequate renal conservation of chloride until the eighth postoperative day. At this time the urinary chloride concentration* showed a sudden and marked elevation, attaining a high of 235 mEq. per liter on the ninth postoperative day, while serum sodium and chloride levels remained below normal. Not shown on the graph were serum potassium levels, checked on four occasions during the postoperative period, varying from 3.7 to 5.2 mEq. per liter; daily urine volumes varying from 750 to 2500 cc., being less than 1 liter on 2 occasions only; and daily volumes of intestinal fluid from the ileostomy tube varying from 600 to 3200 cc.

Fluid and electrolyte replacement was guided by chloride balance studies. Assuming a zero chloride balance the day of surgery, the cumulative balance† did not exceed a plus 300 mEq. chloride during the postoperative period, a figure which was attained on the fifth

* Levels of urinary chloride were obtained from daily urine collections.
† Defined as the difference between the intake and output of chloride from the time balance study began.



GRAPH II. See text for explanation

postoperative day. This slight chloride excess seems unlikely to account for the sudden, increased urinary chloride concentrations beginning on the eighth postoperative day. Consequently, the possibility of adrenal cortical insufficiency was entertained. Desoxycorticosterone acetate and cortisone were given the evening of the ninth postoperative day. Of interest is the sudden drop in urinary chloride concentration with a concomitant rise in the serum sodium and chloride levels. Clinical improvement paralleled these alterations in electrolyte patterns. The daily doses of desoxycorticosterone and cortisone were gradually reduced prior to their withdrawal, the ileostomy tube was subsequently removed, and the patient was dismissed from the hospital on the nineteenth postoperative day.

Case II. D. T. This 37 year old white man was admitted to the hospital on Jan. 8, 1956 with a 20 year history of duodenal ulcer. Bleeding had occurred on 5 occasions within the past 5 years. Three days after admission gastric resection, Bilroth II type, was performed. A stomal obstruction complicated the postoperative course necessitating reexploration on the fourteenth postoperative day. A transgastric jejunostomy with passage of a tube through the stoma into the distal jejunal limb was carried out.

Following this second procedure the stoma remained obstructed for 13 days. A third operative procedure was undertaken, at which time the gastroenterostomy was taken down, the stomach resected at a higher level, and a new gastroenterostomy stoma fashioned.

For a period of 27 days between the first and third operations the stoma was obstructed with resultant intestinal fluid losses as much as 3 liters per day. Water and electrolyte balance was reasonably well maintained throughout this period. Of interest are the electrolyte values in the daily urine collections and the serum following the third operation (graph II). The serum sodium and chloride levels remained low in spite of the administration of corticosteroids and intravenous saline. In contrast to case I normal saline solution was given in excess of balance requirements. This excess was largely excreted in the urine, as reflected by the elevated urinary concentrations of both sodium and chloride ions. Only as his general condition improved, as indicated by a decline in pulse rate, increasing alertness, and tolerance for oral intake, did his serum electrolytes return to normal.

COMMENTS

The conversion of a salt losing kidney to its normal role as a salt conserving one by the administration of desoxycorticosterone acetate has been recently advocated as a definitive diagnostic test for adrenal cortical insufficiency.[15] Since the

test is aimed at only one adrenal cortical function, i.e. salt excretion mediated through its mineralocorticoid fraction, it is conceivable that deficiency states of other fractions, if existent, are undetected by this method.[6] Furthermore, recent observations in the course of metabolic studies following surgical trauma have demonstrated the return to normal of steroid levels before sodium excretions.[13, 23] This "dissociation", while not clearly understood, suggests that extraadrenal factors in response to trauma are involved in the excretion of salt. Thus, this test as a procedure diagnostic of adrenocortical insufficiency awaits clarification.

The electrolyte data obtained in Case I demonstrates a failure of the kidney to conserve chloride, and presumably sodium as well, although urinary sodium determinations were not obtained. The change in the direction of renal conservation of chloride with a return of the serum sodium and chloride levels to normal, occurring within a period of 48 hours following the administration of desoxycorticosterone acetate and cortisone, at least suggests adrenal cortical insufficiency. The possibility, however, that this change was merely coincidental to the administration of steroids has not been excluded. While some experimental observations in animals lend substance to the suggestion that stress may be associated with a relative acute adrenocortical insufficiency,[8, 20, 25] other experimental observations are contradictory.[9, 14, 24] Likewise observations in patients have been contradictory. Aside from conclusions based primarily on impressions, controlled studies on surgical patients with intact adrenals suggest that postoperative shock is little influenced by corticosteroid administration.[1, 7, 10, 11, 16]

Until such time as adrenocortical insufficiency can be more readily and specifically diagnosed in the acutely ill surgical patient, urinary and serum electrolyte studies properly interpreted offer convenient clues to the institution of rational therapy. Such clues when correlated with sound clinical observations of the patient's progress will serve to limit purely empirical therapy, which is all too frequently employed in the treatment of the acutely ill surgical patient.

SUMMARY

The value of urinary electrolyte data in the acutely ill surgical patient presenting fluid and electrolyte problems has been stressed. Such data when correlated with serum electrolyte levels provide information necessary for definitive treatment. Electrolyte studies, reported on 2 cases, are interpreted in order to exemplify their value in treatment. One case demonstrated on electrolyte imbalance consistent with adrenocortical insufficiency; the other an imbalance typical of the so-called sodium paradox.

The difficulties encountered in attempting to verify a suspected diagnosis of adrenocortical insufficiency occurring in a patient with intact adrenals subjected to stress are mentioned.

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SURGICAL MANAGEMENT OF MASSIVE GASTROINTESTINAL HEMORRHAGE OF UNDETERMINED ORIGIN

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Minor hemorrhages of the upper gastrointestinal tract present no insoluble diagnostic problem, in contrast to the severe acute hemorrhage usually designated "*massive*". We are not partial to the word "*massive*". The average patient is almost terror stricken by the sight of blood arising from an internal organ, and his estimate of the extent usually is exaggerated. It would seem more logical to apply "*critical*" as a descriptive word.

Gray, Shands and Thuringer[2] have made a noteworthy contribution to this subject in their review of the cases of all patients whose major complaint was gastrointestinal bleeding. Through a 10 year period, during which 3,500 gastric resections were done, they found 48 in whom no cause was found at operation for hemorrhage. Twenty-eight of these patients underwent exploration, but no definitive operation on the gastrointestinal tract was performed. Sixty-three per cent experienced recurrence of hemorrhage within 5 years. Twenty patients had partial gastrectomy, although the sources of hemorrhages had not been identified.

Twenty-five per cent of the patients in whom the sources of hemorrhage were not found, but had resection, showed ulcers when the specimens were examined after removal. We cannot escape the conviction that many ulcers were overlooked.

Amendola[1] has made a valuable contribution to this subject and states that the examination in the type of case under discussion is not complete with only palpation and inspection of the area in question. If he fails to locate the bleeding in a routine examination, he opens the stomach and duodenum, removes the contents, and after saline solution irrigation, makes an intensive search for the bleeding point. There is no doubt that this approach is rewarded by the discovery of ulcers otherwise missed. If none is found, he does not resect.

It has fallen to the lot of almost every general surgeon to be confronted with the following situation: The patient is admitted to the hospital in shock, after hematemesis or evacuation of a large, tarry stool. The pulse is compressible and rapid, the systolic blood pressure is less than 100, the skin cool, moist and dusky, the patient rational but uncommunicative. The history obtained may be strongly suggestive of ulcer, or on the other hand, may be sketchy and worthless. The laboratory will confirm the loss of blood, but not the source of the bleeding. The roentgenologist may be helpful, but he will not be enthusiastic about the examination in such a case because in addition to the risk incurred in carrying out the accepted technic, the information derived from the examination is likely to be equivocal.

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The presence of blood in the viscera, the reluctance to compress the abdomen to force barium into a possible crater, the manipulation and posture essential to a fluoroscopic examination are deterrent or prohibitive factors in a satisfactory roentgen diagnosis. Hampton has recommended a method of examination that has some advocates, but it has been disappointing and, at times, impossible and impracticable in very ill patients.

There are numerous contributions to the literature on indications for operations in critical gastrointestinal hemorrhage, but no specific or inviolate rules can be applied to all cases, as there are many symptomatic variants, such as the age of the patient, presence of arteriosclerosis, previous hemorrhages and concurrent diseases—to note a few.

In the presence of a critical hemorrhage, the optimum time to resort to surgical measures is not a textbook decision. Spontaneous arrest of the hemorrhage is frequent, but unpredictable. The situation demands team work, and the surgeon, internist, pathologist and anesthesiologist should be part of the team. Do not underestimate any one of them. The administration of anesthesia demands the utmost skill and mature judgment.

Treatment: A long upper midline or right rectus incision is necessary to give ample exposure. The majority of the hemorrhages arise in the duodenum and it should be critically inspected. Stippling may offer a clue. Ulcers in any portion of the duodenum may be palpated while there may be no visible evidence of one. The stomach should be visualized as far as possible, and this leaves something to be desired. Ulcers which may be invisible can be felt between the fingers on the posterior wall and high on the lesser curvature.

Lateral extension of the wound may be necessary to explore thoroughly. Bleeding ulcers usually are not in the proximal third of the stomach. If neither organ discloses a lesion, the condition of the liver should be noted. If it is immediately apparent that cirrhosis is the etiology, then a different type of surgery is in order. In the absence of liver pathology, the entire small intestine should be examined by inspection and palpation, beginning at the ligament of Treitz and continuing to the ileocecal valve. Neoplasms in the small bowel are unusual, but may, like Meckels' diverticulum, be responsible for the hemorrhage. The treatment is resection.

Should no cause for the hemorrhage be found, the duodenum should be opened, emptied and examined. In the absence of an ulcer, the stomach should be opened on its long axis. If it contains blood, only removing clots and liberal irrigation with saline solution will permit an adequate examination of the interior. Even when a large amount of blood is evacuated, no bleeding may be seen. Some authors are of the opinion that copious bleeding may arise from a diffuse inflammation of the gastric mucosa, but our experience does not substantiate such a view.

Bleeding is likely to arise from a small artery which becomes invisible because it has retracted, with cessation of bleeding. It may not occupy an area of gross ulceration. In all probability, it is the result of a small embolus that has eroded a

vessel. The bleeding point is not readily detected, but the bleeding will recur when the blood pressure is restored by transfusions.

We have had 2 such experiences. In each patient, the stomach had been opened, the liquid and clotted blood removed and no bleeding point found. Under intra-arterial transfusion, the pressure was raised and the bleeding was activated. The artery projected and spurted through the mucosa and was easily recognized. A transient and rapidly acting vasopressor, such as levo-phed, may be useful under the same circumstances, but we have not had an opportunity to use it for this purpose.

Resection of the area involved is the treatment of choice, although some are content to tie the bleeding vessel. The more radical operation (resection) is less likely to be followed by recurrent hemorrhage and more likely to give permanent relief. An ulcer is not cured by controlling the hemorrhage.

If the bleeding is not discovered by this method of examination, it is better to close the duodenum and stomach, rather than resect. Ruptured varicosities in the esophagus and stomach, as a result of cirrhosis of the liver, often are the cause of hematemesis.

SUMMARY

Critical hemorrhage from the upper gastrointestinal tract usually originates in an ulcer, and prompt surgical treatment is necessary. If operative measures are employed, it is necessary to control the bleeding at its origin. According to reliable data, 25 per cent of the patients in whom the source of hemorrhage was not found upon routine examination, showed peptic ulcers in the specimen removed. It behooves the surgeon to use every available means to find the lesion and treat it as his judgment dictates.

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NEONATAL RESPIRATORY PROBLEMS EXCLUSIVE OF CENTRAL NERVOUS SYSTEM CAUSES

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In the newborn infant respiratory difficulties are frequently seen by the attending obstetrician and pediatrician. A large proportion of these are readily managed by aspiration of the hypopharynx, relieving obstructing mucus and meconium. Central nervous system depression due to one of several readily explained causes, including birth trauma, is usually no major diagnostic problem as far as infant resuscitation is concerned.

DISCUSSION

It is our intention to emphasize the more subtle causes for persistent respiratory distress during the newborn period and to indicate the currently acceptable means for their diagnosis and treatment. No one individual syndrome accounts for any but a very small percentage of the problems in the newborn patient, but collectively these conditions comprise about 5 per cent of all neonatal problems.

Obstructive atelectasis due to aspiration constitutes the most common cause for persistent respiratory distress. Roentgenologic and clinical diagnosis alone can be misleading, and fluoroscopic examination should always be done as a confirmatory procedure. Mediastinal flutter and diaphragmatic paradox during inspiration are highly suggestive of obstructive atelectasis. Fluoroscopy also will serve to differentiate between atelectasis and obstructive emphysema with a ball valve type of obstruction. Direct laryngoscopy and tracheal catheter suction frequently will suffice in relieving such a condition, but if unsuccessful, then immediate bronchoscopy should be carried out. When done adroitly, this procedure need not be traumatic nor necessarily followed by the need for tracheotomy, a fear so often expressed by pediatricians. Figure 1 demonstrates a pre and postbronchoscopy roentgenogram on an infant suffering from severe atelectasis. This child did extremely well following a bronchoscopy, performed on the third day of life.

Esophageal atresia with or without tracheoesophageal fistula is a condition which is readily diagnosed only if the possibility is considered. The presence of excessive mucus and immediate persistent regurgitation should alert all in contact with newborn children to this possibility. Suspicion of the diagnosis can be supported when it is found impossible to pass a catheter into the lower esophagus. Roentgenologic and fluoroscopic confirmation are readily obtained by giving the infant a swallow of lipiodol. The presence of a fistulous communication between the lower esophageal segment and the trachea can be assumed if gastrointestinal air is seen on the roentgenogram. Such a condition is not long compatible with life and requires early and prompt surgical correction. Aspiration of ingested

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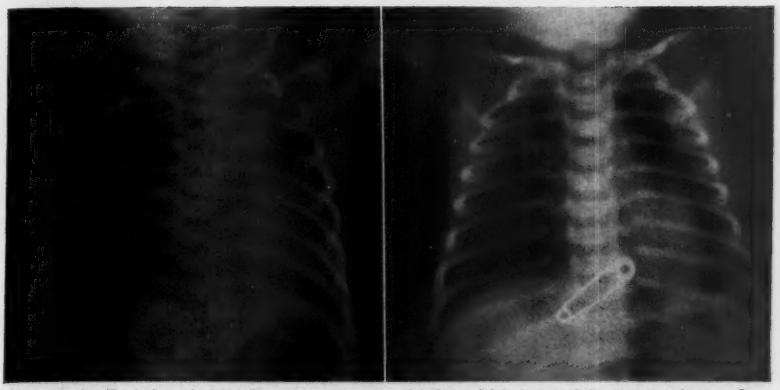

FIG. 1. A. (Left hand side) Roentgenogram of 3 day old infant with obstructive atelectasis of the left lower lobe. B. (Right hand side) Roentgenogram of same infant shown in figure 1A 1 hour after bronchoscopy.

material from the pharynx and also regurgitation of gastric contents into the trachea via the fistula will lead to a rapid deterioration from pneumonitis, regardless of the element of starvation which the atresia imposes on the infant. The early diagnosis of this condition is the one controllable factor which will determine the success or failure of the corrective surgery. Figure 2 demonstrates the various types of tracheoesophageal fistulas which can occur. Figure 3 shows the postoperative roentgenogram following re-establishment of continuity in a previously atretic esophagus.

Another esophageal abnormality, although admittedly rare and not quite so easy to diagnose, is that of a congenital web, or diaphragm, of the esophagus. Figure 4 demonstrates a barium swallow in such a case. The presence of an incomplete esophageal obstruction usually is manifested by regurgitation, choking on feedings, particularly as the individual's diet is increased to include other than liquid elements. Such a history should lead to immediate lipiodol visualization of the esophagus. Careful fluoroscopic and roentgenologic examination is necessary to detect such a lesion and its presence can only be absolutely ascertained by a careful esophagoscopy. The use of thick barium may sometimes be necessary before the true nature and location of the partial obstruction can be detected. A transthoracic approach to the esophagus with esophagotomy and resection of the offending diaphragm is a relatively simple and completely curative procedure, once the diagnosis is made.

A condition with similar presenting symptoms of partial esophageal obstruction is that of the congenital vascular ring, or double aortic arch. In this condition the aortic arch persists as a double vascular structure often giving rise to aberrant left or right subclavian arteries. The arch itself, or one of its aberrant branches, can so compress the esophagus from behind, as well as the trachea in front, as to give rise to regurgitation and aspiration as well as stridorous breathing. Again lipiodol visualization usually will be diagnostic and prompt surgical correction

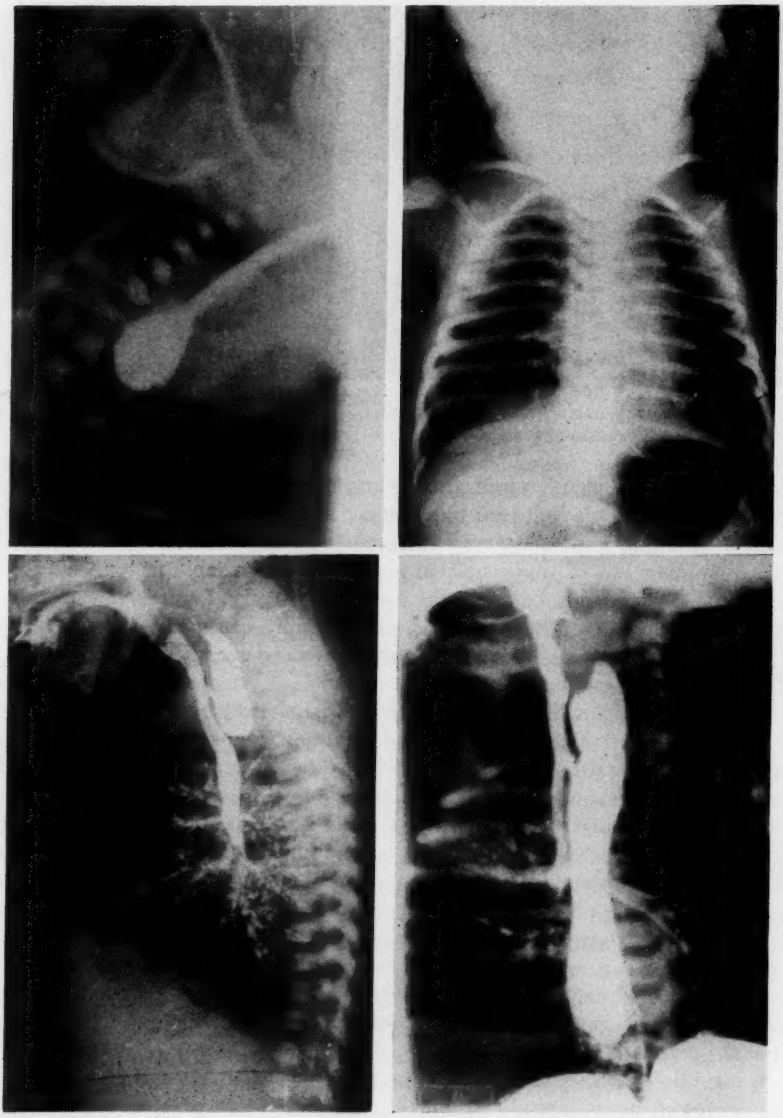

FIG. 2. A. Lipiodol visualization of blind esophageal pouch in congenital atresia. B. Posteroanterior exposure of same infant shown in figure 2A with catheter coiled in proximal esophagus. Air bubble noted in stomach confirms presence of a tracheo-distal esophageal fistula. C. Esophageal atresia with tracheo-proximal esophageal fistula. No air noted in gastrointestinal tract. D. Tracheoesophageal fistula without atresia.

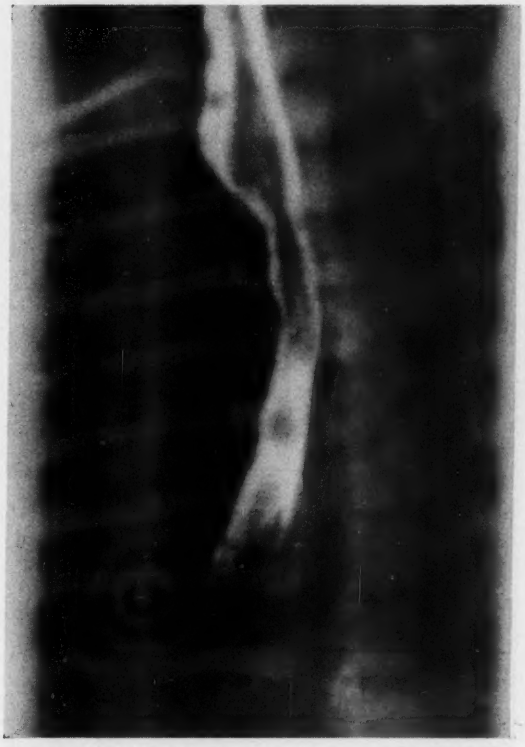

FIG. 3. Postoperative lipiodol visualization of reconstructed esophagus in same case shown in figures 2A and B.

is mandatory. The details of the anomaly will dictate the exact point of division of the arch or one of its major branches with expected complete relief of the classical picture of posterior indentation of the upper esophagus from the posterior portion of the double aortic arch. The presence of extensive preexisting aspiration pneumonitis is the most serious deterrent to obtaining a satisfactory result from the surgical correction of this condition. This child was operated upon before he had developed any severe degree of aspiration pneumonitis and followed an uneventful postoperative course with complete relief of symptoms.

Congenital diaphragmatic hernias in the newborn carry a very serious prognosis. Failure of fusion of the pleuroperitoneal membrane, leaving a defect in the posterolateral portion of the diaphragm, the so-called foramen of Bochdalek, is the most common site of such a hernia. It is seldom symptomatic on the right due to the protective influence of the liver, but on the left varying degrees of herniation of abdominal contents into the left hemithorax will occur. As the gastrointestinal contents of such a hernia become distended with swallowed air, their expansion within the thorax will rapidly cause mediastinal shift and severe

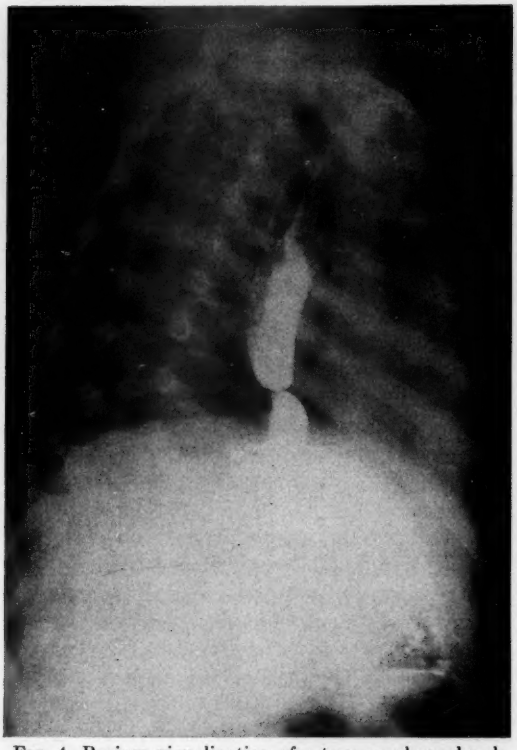

FIG. 4. Barium visualization of a true esophageal web

respiratory embarrassment. The presence of bowel sounds within the chest, associated with mediastinal shift to the opposite side is diagnostic. A scaphoid abdomen frequently is seen in these patients. Roentgenologic examination of the chest and abdomen with a catheter in the stomach will be diagnostic. Continuous gastric suction is instituted and with no other special preoperative preparation, immediate surgical repair must be carried out. Figure 6 demonstrates such a case before and after surgery. The thoracic versus the abdominal approach is, we think, a question of personal experience and preference in these cases.

Spontaneous pneumothorax due to congenital cystic disease of the lung, without underlying pneumonia, will lead to progressive dyspnea and may defy clinical diagnosis in a newborn. Roentgenologic diagnosis, however, usually is absolute. It is not the purpose of this paper to go into a detailed discussion of the pros and cons of congenital cystic disease and its prognosis; but if spontaneous pneumothorax develops, prompt pleural decompression, preferably by means of an intercostal catheter, can be life-saving. The initial diagnosis and treatment are basically so simple that a neonatal death from such an unexpected situation is almost inexcusable.

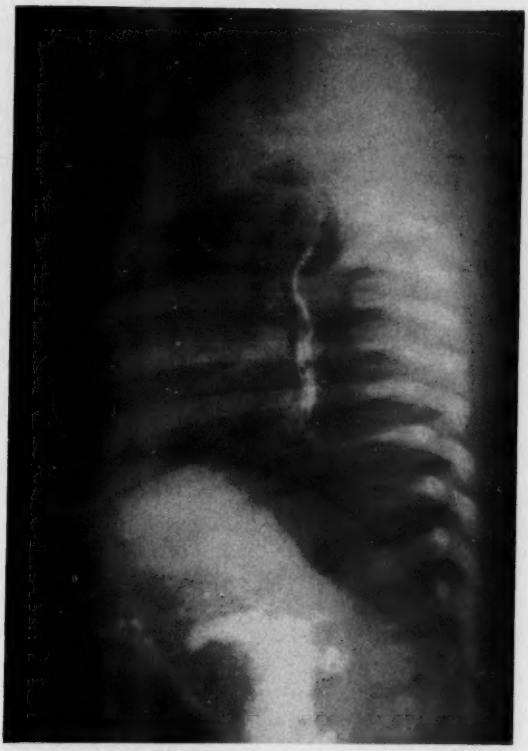

FIG. 5. Lipiodol visualization of the esophagus in the lateral projection showing typical posterior indentation of the esophagus in a case of double aortic arch.

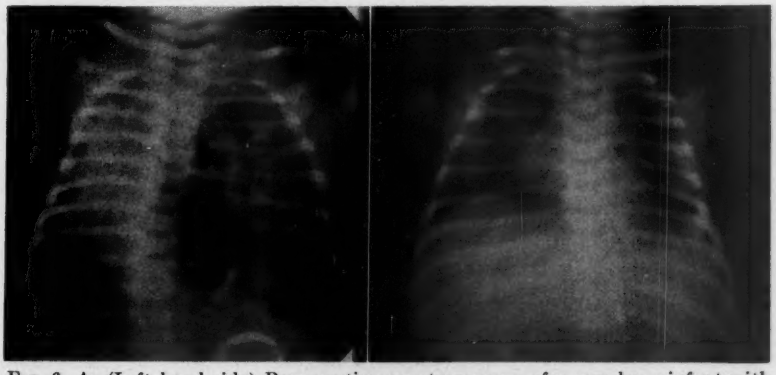

FIG. 6. A. (Left hand side) Preoperative roentgenogram of a new born infant with a congenital Foramen of Bochdalek hernia on the left. The left hemithorax contains herniated stomach and intestine. There is severe mediastinal shift to the right and marked compression of the right lung. B. (Right hand side) Postoperative film on same child shown in figure 6A.

The thymus gland, of course, always manages to project itself into such a discussion as we are undertaking. Actually, the thymus has little or no place in such a discussion. It has been miscast in the role of mediastinal villain, except in the very rare case of an annular thymus, which clinically and roentgenographically cannot be distinguished from the double aortic arch. Surgical exploration, as indicated by positive roentgenograms, will reveal the true nature of the constriction, and partial or subtotal thymectomy will be curative. We mention only to condemn the use of so-called therapeutic trials of X-ray therapy. Valuable time in relieving mechanical obstruction will be lost while ineffective X-ray is being given. If the X-ray therapy is successful, then the false assumption that the thymus is responsible will be made and possibly a mediastinal lymphoma or other mediastinal tumor will go unrecognized and inadequately treated.

Bilateral agenesis of the lung is, of course, immediately fatal. Unilateral agenesis occurs with great rarity and most often is seen in association with a congenital diaphragmatic hernia. The diagnosis in these cases will be made at the time of the herniorrhaphy, and the prognosis is very poor. In the isolated case, the diagnosis is extremely difficult because of the simulation it bears to obstructive atelectasis. There is, of course, no satisfactory treatment, so that error in diagnosis is not too serious, provided an obstructive atelectasis is considered and found not to be present.

Another rare and extremely baffling syndrome, unless considered early as a cause for respiratory distress, is a bilateral choanal atresia. In this condition the choanal plate, which forms the superior portion of the nasopharynx, is imperforate. Mouth breathing is a conditioned reflex not yet acquired in the newborn. Therefore, if the posterior nares are imperforate, the child will be unable to breathe, unless the mouth is kept open. The clinical picture is that of hypopharyngeal obstruction, which responds immediately to opening the mouth and pulling the tongue forward. This response usually serves to focus one's attention on such suspected defects as tracheal or laryngeal malformations but none are found. If, however, the possibility of choanal atresia is considered, the inability to pass a small probe into the nasopharynx via the nares will establish the cause of the trouble and proper treatment can be instituted. According to our otolaryngologic confreres, the emergency treatment may be very satisfactory but the eventual prognosis is poor.

The last condition, which must be considered among the causes of respiratory disorders in the newborn, is the poorly understood and much discussed problem of the hyaline membrane. It consists of a fibrin-like deposit in the bronchioles and even alveoli of the lung, which histochemically resembles fibrin. Whether it represents endogenous secretion, which has undergone solidification in the presence of the highly fibrogenic amniotic fluid in uterine life; or, whether it represents aspirated meconium, is still being debated in the quiet of the laboratory. There is no successful method of handling this problem, other than the mechanical removal of material from the larger air passages by the conventional means of catheter suction and bronchoscopy. Both of these methods fail in relieving alveolar and bronchiolar obstruction. The prognosis in the diffuse cases of hyaline

membrane is almost uniformly hopeless. Needless to say, it is not a surgical problem except for its diagnostic implications.

SUMMARY

In summary, we would like to re-emphasize the importance of an orderly, systematic evaluation of dyspnea and respiratory embarrassment in the newborn. After the routine suctioning and cleansing of the upper respiratory passages have failed to relieve respiratory difficulty, there are certain measures which should be taken to include or exclude rather rapidly and completely any of the aforementioned conditions capable of causing such trouble. A very careful inspection of the child will reveal any gross differences in hemithoracic excursion. Obvious displacement of the visible point of maximum impulse will be suggestive evidence of mediastinal displacement. A scaphoid abdomen should suggest a diaphragmatic hernia. Percussion and auscultation of the chest will reveal absence of normal breath sounds over areas of atelectasis or pneumothorax. The presence of bowel sounds in the chest will make obvious the diagnosis of hernia. The simple expedient of passing a small rubber catheter into the esophagus will demonstrate an esophageal atresia. Roentgenologic and fluoroscopic confirmation of these suggested findings usually will direct the proper course of action therapeutically. The diagnosis is not difficult of attainment if the possibility of such anomalies is known and considered routinely in the appraisal of all such children.

Editorial

PROGRESS IN THE DEVELOPMENT OF ARTERIAL PROSTHESES

Despite 50 years of investigation in the field, we, as surgeons, do not know what material will provide for us the ideal in vascular replacement. During the course of the 50 years we have, through trial and error, accepted certain materials and rejected others, using the gross criteria of functional success. Cumbersome and inaccurate as this method is, it has permitted the rapid strides in therapy by vascular replacement that have figured prominently in the literature over the past eight years. It may be argued that the ultimate in functional success is sufficient unto the patient; however, we believe that the ideal material should be determined through understanding of the mechanism of vascular repair in the host. In the past, practical difficulties have hampered our understanding of the respective roles of the donor and host tissue in the ultimate product of repair where the vessel replacement was of animal origin. Recently, with the advent of the permeable plastic prosthesis, the host response can be more accurately identified and evaluated. It is our hope that from these studies we may be in a position to prophesy, perhaps achieve, the ideal vascular replacement.

Let us, for the moment, assume that we have by selection eliminated those vascular replacements that have had a high incidence of early functional failure. The serious investigator will join me in conceding that making direct comparison of the best available homograft and the best available biologically inert plastic prosthesis would be a violation of a fundamental scientific rule at this time. It is reasonable to suppose that both the homograft and the inert prosthesis ultimately will undergo complete degradation. It also is reasonable to predict that the applied clinical value of these vascular replacements will be assessed by the rate of degradation and by the coincident host response to the replacement as it loses its initially desired qualities. At this time, however, studies have been of insufficient duration to evaluate anything but the early functional success rate.

At Presbyterian Hospital 80 odd inert plastic prostheses have been implanted as partial replacements in central and peripheral arteries in man and several hundred in dog. Concurrently a series of equal magnitude has been compiled where the homograft has been used. All our experience to date has been collected and examined with care over a maximum follow-up period of five to six years, and we feel certain that we have insufficient data to allow for critical evaluation.

It has been our impression from admittedly early studies that the reparative process of the host derives its origin and subsequent support from the surrounding soft tissue and the host vessel and not from the passing blood; therefore, any

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material, animal or synthetic, that presents a barrier will impede this process of repair in direct ratio to its efficiency as a barrier. Furthermore, any local or general host environmental deviation from the normal will alter the process of repair. Thus, we must assume that repair in any area of relative ischemia will differ from repair in the normal and that perhaps minor differences seen in the normal experimental animal will be exaggerated when the same replacement is used in an ischemic extremity of an individual with arteriosclerosis.

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